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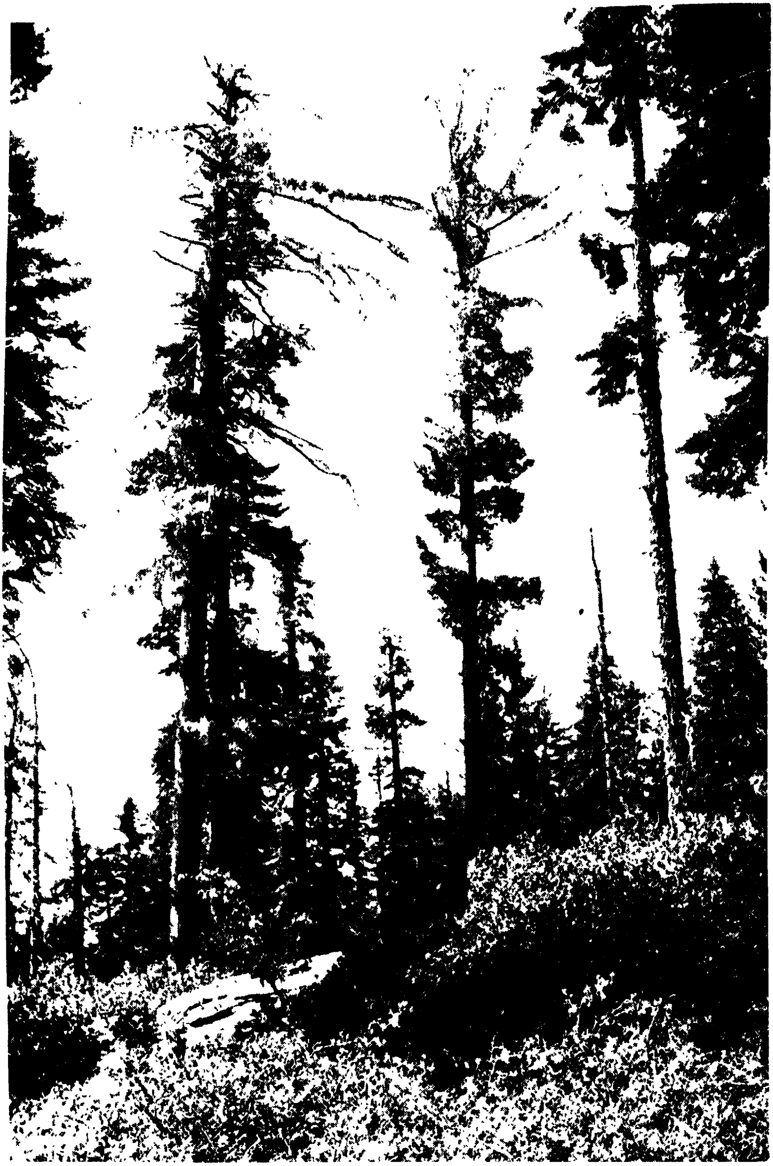

FRONTISPIECE.—Two large sugar pines attacked by the mountain pine beetle, *Dendroctonus monticolae* Hopk., in General Grant Park, California. Tree on right is infested as shown by fading foliage from top down to midsection. Tree on left has reached the red-top stage and has been abandoned by the beetles. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Photo by Miller.*)

FOREST INSECTS

A Textbook for the Use of Students in Forest Schools, Colleges, and Universities, and for Forest Workers

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PREFACE

The awakened interest in forestry has manifested itself in renewed efforts in forest conservation and in the reforestation of denuded areas. Along with this there has, of course, been an ever increasing interest in the insect pests of our forests for we now know that the insects rank with fire as important destructive factors in many of our large forest areas. In reforestation projects they may also be of much importance, for the young growing trees are very susceptible to their attacks.

The literature dealing with the insect pests of our forest trees is, except for Graham's "Principles of Forest Entomology," which deals largely with principles, especially from an ecological viewpoint, scattered throughout various journals and state and government publications, many of which are old and now available to but a few.

Forest supervisors, rangers, park superintendents, timbermen, and many others who are constantly in need of reliable information on this subject are seriously handicapped because of this condition. In forest schools, colleges, and universities where courses in forest entomology are taught, the teachers and the students keenly feel the need of some organized source of information, not only as to the insects that are attacking their trees, but as to the methods of control.

There are several ways in which this subject might be approached. All have their advantages and disadvantages. The authors believe that the plan adopted here is the most straightforward and the one that will appeal to the largest group of workers, students, and readers.

It is obviously impractical to discuss all the important insects of the forest. The list is too long. The authors' aim has been to give a fairly full discussion of one or more insects of each representative group and then to list the others with only short comment. Thousands of kinds of insects are to be found in every forest and grove. Usually only those of some economic importance are listed here. Some of these are of only local interest and occur only at intervals; others are widely distributed and are present in more or less destructive numbers almost every year.

The publications listed in this book are selected because of their general interest or because they give additional information which would be useful to the student who wishes to make more detailed studies of certain insects or groups. Except for the general bibli-

ography given at the end of Chap. I, the references are arranged alphabetically at the end of the chapter to which they are pertinent.

Many of the most important articles relating to forest insects are published in the bulletins or circulars of the Bureau of Entomology and of the Forest Service and in other publications of the Department of Agriculture. The various state experiment stations and universities often publish bulletins or memoirs relating to this subject. The Entomological Branch of the Canadian Department of Agriculture has issued a number of very important bulletins dealing with forest insects in Canada.

The Journal of Economic Entomology, The Journal of Agricultural Research, The Journal of Forestry, The American Lumberman, The Timberman, The Canadian Lumberman, and many other entomological and forest journals and proceedings often have articles giving much interesting and useful information.

Cooperating fully from the beginning of this project, Messrs. J. M. Miller and F. P. Keen of the U. S. Bureau of Entomology and Plant Quarantine have given us much valuable aid and advice. Indeed, without their help, some of the chapters, especially those dealing with control and with the important family Scolytidae, could not have made so full and so authoritative and up to date as they are. Both of these men have had wide experiences in the field and in the laboratories, and their cooperation has been invaluable.

We wish, too, to acknowledge the helpful notes and criticisms made by Dr. M. W. Blackman of the Bureau of Entomology and Plant Quarantine, who has looked over parts of the manuscript.

Most of the illustrations are new and are used here for the first time. The authors are greatly indebted to Dr. F. C. Craighead of the Bureau of Entomology and Plant Quarantine for permission to use the many excellent photographs and drawings made by Messrs. J. M. Miller and F. P. Keen and other members of the Bureau; and for illustrations furnished by Dr. Arthur Gibson of the Canadian Department of Agriculture, all of which are acknowledged in the legends accompanying the figures.

Acknowledgments are also made to Dr. V. L. Kellogg and Henry Holt & Company for permission to use several figures from Kellogg's "American Insects," and to D. Appleton-Century Company for allowing us to use Figs. 8, 201, 202, and 232 from Jordan and Kellogg's "Animal Life."

Photographs and drawings for Figs. 5, 24, 25, 29, 33, 34, 42, 51–54, 57, 59, 60, 63, 65–67, 70, 72–93, 96, 98–100, 102–121, 123, 125–134, 138–144, 150, 188, 192, 209–211, 215, 233, and 234 were furnished by Dr. E. C. Van Dyke. The excellent drawings of beetles and larvae

in this group are from the pen of Mrs. Freda Abernathy. Photographs for Figs. 6, 9, 10, 21, 22, 23, 30, 31, 39, 44, 47, 50, 55, 64, 152, 153, 163 164, 168–170, 172–175, 180, 194, 203, 208, 212–214, 217–219, 221–223, 225 were furnished by Prof. R. W. Doane; for Figs. 26, 58, 68, 124, 137, 145, 148, 154, 155, 167, 186, 187, 198, 204, 227, by Dr. W. J. Chamberlin and for Figs. 147, 220, by Dr. H. E. Burke.

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FOREST INSECTS

CHAPTER I

IMPORTANCE OF FOREST ENTOMOLOGY

When we speak of forest protection, it is usually understood to mean the prevention and suppression of forest fires. This is, of course, one of the important problems in the administration of forests, and it is the one to which in America the greatest attention has been given in organizing the work of the private and national forests along protective lines.

Forest protection does not, however, mean safeguarding against fire alone. Injurious insects and plant diseases may do far more damage each year than fire does. But they do not work in such a spectacular way, and so the injury that they do receives less attention.

The problems of the silviculturists, in many regions, are intimately connected with problems of pure and applied entomology. For this reason it is essential that foresters have a broad understanding of the subject of entomology in its technical and economic phases and that they appreciate thoroughly the importance of the various insects which they may have to combat if they are to bring their crops to a successful maturity.

The study of forest entomology as a distinct branch of economic entomology is comparatively new in the United States. In some of the European countries, especially in Germany and in France, it has long been a subject of special research, and many important publications have been issued. A list of some of the most important books published in the United States and in foreign countries is given at the end of this chapter.

Insects that injure and kill trees are always present and probably always have been a part in the life of every forest. Their abundance, however, is transient and ever changing. Under normal conditions insect numbers are held in check by their many enemies and the unfavorable factors in their environment.

But this normal, balanced condition in a forest is by no means a stable one, and at times certain species of insects may suddenly multiply their numbers and kill a very high percentage of the forest

in the period of a few years. This condition is usually referred to as an epidemic. Outbreak is another term used to describe the condition where insects are killing timber much more rapidly than it is being grown.

In the wild forest lands of the country even the epidemic condition may not be a serious matter in the general scheme of nature. Although an entire forest may be wiped out, a new one of younger trees springs up and in due course of time replaces it. It is only

FIG. 1.—A group of ponderosa pines, in Modoc Area, California, killed by the western pine beetle, *Dendroctonus brevicomis* Lec. This shows the condition of the trees about seven years after they have been abandoned by the beetles. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Photo by Miller.*)

when a forest in its existing condition takes on a definite usefulness to man that we begin to regard these insect outbreaks as an economic evil.

To place a monetary value upon the total damage that insects do to the forests of the United States is a difficult problem, even to those who have had long experience in appraising such losses. To the forester their importance may be measured if we refer only to the loss of increment both by killing the growing trees which compose the ultimate crop and by destroying the final wood product after it has been manufactured. But forestry is also concerned with other values inherent in the forest which are much less easily measured, such as its usefulness for watershed cover and for public recreational purposes and the aesthetic importance attached to trees that are a

feature of great natural areas such as the national parks. Insects, like any other tree-destroying agencies, may affect any of these values.

If broad estimates of damage are attempted, it must be realized that they can be based only on widely separated examples of insect outbreaks which have been studied, representing but a very small cross section of what has been going on throughout the country at large. General observations also may serve as a basis for tentative estimates, but these are equally inadequate and unsatisfactory. The estimator is further confronted with changing basic values of the forest, due to shifting economic factors and the fluctuations of infestations from year to year, so that at best his figures can be of but temporary value and accuracy.

Estimates have placed the total loss of forest resources due to insects at more than $200,000,000 annually. The probability of error in such estimates depends necessarily upon interpretation of values and the applicability to the entire country of the actual examples that were studied by the estimator.

HOW INSECTS ATTACK TREES

No part of the tree is immune to insect attack. The potential tree, as represented by the seed, is subject to destruction by cone beetles, certain moths, maggots, and tiny chalcid wasps. The seedling may be stripped of its leaves by defoliators, girdled by bark beetles or weevils, or grubs living in the soil may destroy the root system. The sapling, the pole, and the mature giant of the forest have enemies of root, bark, limbs, and foliage. Serious damage to any one of these parts may either kill the trees outright or so weaken them that they become a prey to other insects. Wood borers work in the sound wood of standing or fallen trees or in logs. Even rough lumber, poles, posts, ties, and other forest products are subject to attack. And the end is not yet, for certain beetles work in finished products, such as furniture, cooperage, implement handles, and even in the woodwork within our homes.

The manner in which insects go about their attack on various parts of the tree makes possible their rough classification by groups without regard to systematic relationships. Workers in forest entomology have recognized the following groups, based primarily upon types of injury:

The Bark Borers.—This group includes some of the most destructive species with which we have to deal. The greater number are small cylindrical beetles belonging to the family Scolytidae. The adults of this family bore through the outer bark and extend egg galleries in the cambium which deaden the tree by a girdling process.

The larvae then feed upon the same parts of the tree. Certain flathead borers (Buprestidae) and roundheaded borers (Cerambycidae) also belong to this group, the adults merely laying their eggs on the outer bark, and only the larvae mining the cambium. In all species included in this group, however, the larvae chew their food and extend mines by gnawing their way through the plant tissues.

The Wood Borers.—These insects are mostly beetles the larvae of which bore their way through the hard wood of the trunk and limbs. A number of families are represented, but the more common ones are roundhead borers (Cerambycidae) and flathead borers (Buprestidae). Some of them attack living trees, but most attack the wood only of injured, dying, or dead trees. Their work is therefore rarely of importance in causing the death of trees, and, except for insects like the locust borer, they are of most concern in causing defects in lumber. Many of them breed only in old rotting wood and are of benefit in hastening the disintegration of forest debris.

The Leaf Feeders.—These are usually caterpillars, sawfly larvae, or adult beetles which feed on the surface or within the leaves and chew their food. Under endemic conditions their numbers are so limited that they cause little or no injury to the trees; but when outbreaks occur they may cause complete defoliation of trees over large areas. Where the terminal buds are destroyed, such defoliation usually proves fatal to the trees. If the defoliation is not complete, and the buds are not injured, the trees are retarded in their growth and may recover or later succumb to the attacks of bark borers.

The Sapsuckers.—This group includes such insects as plant lice (Aphididae) and scales (Coccidae) which have mouth parts adapted to sucking plant juices. This process diverts the sap, which would naturally go into the wood-building process, to the nutrition of the insects. The result is somewhat similar to that resulting from defoliation. While this group is of great concern to the agriculturist, and its members are important enemies of park and shade trees, they do not so seriously interest the forester except when they attack young trees or nursery stock. Comparatively little serious loss in the forest is caused by sapsucking insects.

There are, of course, still other types of injury produced by insects which do not fall conveniently within the broad classifications outlined above. Such are the seed-mining chalcids (wasps), the cone worms (caterpillars and maggots), the root feeders (beetle larvae), and the gall makers (wasps and aphids). The root feeders are often extremely important in nurseries and young plantations. However, these insects do not destroy the mature timber crop; and in considering the more serious losses of forest resources we are concerned mainly

with insects that cause the four major types of injury which have been described.

THE ROLE OF INSECT DAMAGE IN FORESTRY

This ability of insects to attack the tree in all its phases of growth and usefulness affects the practice of forestry both directly and indirectly. They cause a direct loss by killing trees that might otherwise have been ultimately sold and harvested (stumpage), the loss of growth increment due to the defoliation of living stands, and the loss of revenues from recreational uses of the forest when

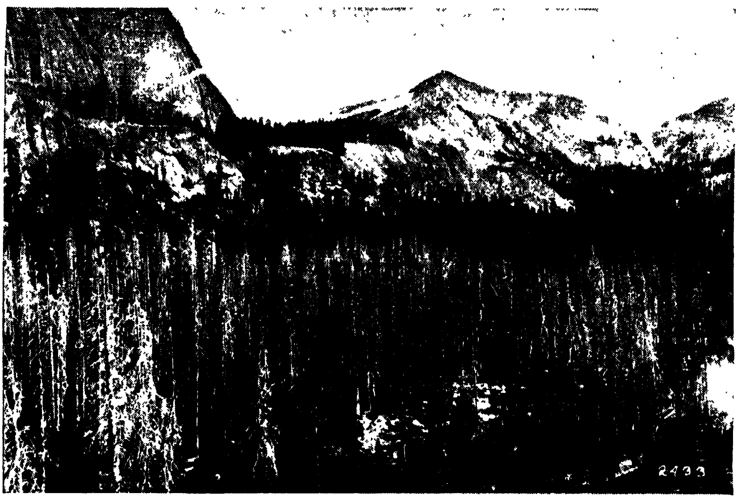

FIG. 2.—Dead lodgepole forest in the Tenaya basin, killed by the mountain pine beetle, *Dendroctonus monticolae* Hopk. Unaffected forests in the background composed of California red fir and mountain hemlock which are immune. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Photo by Miller.*)

trees are killed. Indirect losses are those such as the increased cost of fire protection due to the accumulation of dead snags, the reduction of logging profits in areas that have been heavily thinned by insect outbreaks, and the reduction of stumpage prices due to the threat of infestations.

In growing timber as a crop the maximum net yield of wood from a given area is one of the goals with which the owner and forester are concerned. In every heavily stocked young forest there are thousands of trees that must die and pass out of the picture before the forest reaches maturity. There is not enough room for all trees to reach their maximum size, and some sort of thinning must therefore take place. In intensively managed forests man has recognized this need and carries out a program of systematic thinning. Nature takes care

of this same need through suppression of slower-growing trees; and at times insects and disease may serve a useful purpose in removing trees from overcrowded stands, thereby releasing the space to the surviving trees which will then grow more rapidly and into better wood material.

Effect upon Mature Timber.—Up to the time that a forest approaches maturity, the loss of a few trees here and there is not a serious matter and may even be a benefit. When one tree dies the survivors near it speed up their rate of growth, and the loss of potential lumber is soon replaced. The final net yield of the area will not be affected so long as the normal density of growing stock is maintained.

As these stands of timber approach maturity the loss of individual trees becomes a more important factor in the yield, as this loss may not be replaced by the time that the crop is harvested. When insect outbreaks of an epidemic character kill a high percentage of the trees there is little hope that this loss will be compensated by growth for many years; and unless this dead timber can be salvaged, logging must be delayed until another crop of trees has been grown before a profitable cut will be possible.

The most serious losses that affect the lumberman are those occurring in accessible stumpage which is to be marketed within a decade or two. There is little possibility that severe losses due to insect epidemics will be replaced by natural growth within this period, so that practically every tree taken by the insects is lost to the sawmill. Not only the loss of stumpage itself, but the increased overhead of logging costs in heavily thinned stands, must be charged against the infestation, as well as the community loss due to reduction of the product sold from the region.

Effect upon Forest Management.—Once the mature timber has been cut, forest lands must be kept in a state of production if they are to continue to yield revenues and pay the costs of taxes and protection. This means that growing stands of young trees will need to be protected for long periods from fires and the threat of disease and insect outbreaks. Insects rarely kill these young stands entirely, but they often cause serious injuries. The white pine weevil may degrade the quality of the lumber product, or the fir engraver beetle may kill the tops and permit the introduction of wood-rotting fungi.

In many regions the most serious threat to second-growth stands is that resulting from defoliations. Epidemics of defoliating insects, even though they do not kill the trees, may be responsible for retarding the growth to such an extent that at the end of a fixed rotation period the yield from an acre will be much less than expected. Sustained yield from a given area, the goal of forest management, is an

impossible attainment where insects or other causes interfere with the length of rotation and reduce or degrade the output upon which the forester has carefully planned his program.

Effect upon Reforestation.—Where planting is resorted to for the restocking of denuded and cutover areas, the cost of reforestation is much greater than where natural reproduction can be depended upon to establish the growing stock. Under either system the availability of a good supply of sound seed is necessary. Here we find that insects are again a factor, particularly those that attack the seeds and cones of conifers. Small scolytids attack and kill the immature cones, the larvae of certain chalcids live within the seed, and the larvae of moths and certain flies feed upon the immature growing tissues of the cones and seeds. Man of these insects have made special adaptations in their life history to conform to the fruiting period of their host. Conifers produce abundant seed crops intermittently, usually in alternate years, and certain insect species that depend upon the young cone entirely for food will remain in a dormant condition for one and even two seasons, so that the flight of the adults is timed with the cone-bearing habits of the host tree. The control of insects that attack forest seed crops has been given little attention up to the present time. It is evident, however, that certain types of this damage, as well as that occurring in seedling and very young trees, will have to be minimized or controlled as the restocking of cutover and denuded areas becomes more of a factor in the production of future timber crops.

Recreational and Other Uses.—In many parts of the country one of the important uses to which forest lands are put is for recreational and summer-home purposes. Both on national forest lands which are leased and private lands which are sold for such purposes, the natural cover of forest growth is considered one of the greatest assets. The value of the land is to a very great extent determined by the availability of trees as shelter for cabins and by the aesthetic interest that they give to the surroundings. The killing of the trees on these sites in many regions has become a matter of concern to the public and owners. Control under these conditions often warrants the use of methods employed for protection of park and shade trees.

Increased Fire Hazards.—Insect epidemics usually leave in their wake an accumulation of dead material which in dry periods adds tremendously to the inflammability of the cover. Once a fire gets underway in these deadenings its spread is much more rapid than in stands composed entirely of living trees. Not only do the accumulations of snags add to the available fuel, but when the snags continue to burn for hours and sometimes for days in a standing position, throwing burning embers for long distances, fire lines in the region are

untenable. Increased costs of fire suppression and increased fire damage are the effects which remain long after the insect outbreaks that caused the snags have subsided.

FOREST-INSECT PROBLEMS IN DIFFERENT REGIONS

Nearly all species of tree-killing insects show a decided preference for specific host trees. Some, like the western pine beetle, confine their attention almost entirely to one tree species and disregard other closely allied trees which may be growing in mixture with their favorite host plant. Epidemics, however, do not develop with any great regularity, nor do they spread with the same intensity throughout the range of these selected tree species. Local conditions, probably due to the influence of climatic and other factors, produce differing situations of varying degrees of importance in every forest region.

For these reasons we find that each forest region has its own peculiar infestation problems with which the forester must contend. An insect that is of outstanding importance in one region may be of minor significance in another. There is also a multiplicity of problems in each region, owing to the combined infestation of several insects in the same forest area, and overlapping of the same insects occurs between regions. The field, therefore, is a very complicated one.

Between the eastern and western parts of the United States and Canada the problems of forest protection which develop as a result of insect infestations differ as greatly as do the climatic and forest-type conditions of these two general regions.

The great proportion of hardwood forests in the East has brought into prominence many insects, like the locust borer and gypsy moth, which attack broadleaf trees; and the development of planting and more intensive forestry to replace the original virgin stands that have been cut over has emphasized the damage done to trees in the earlier growing stages by insects like the white pine weevil. Some of the more important problems, therefore, are those of second-growth stands.

In the western United States, from the Rocky Mountains to the Pacific Coast, coniferous forests predominate: and here we find that tree-killing bark beetles, particularly those belonging to the group known as Dendroctonus beetles, stand out prominently as the major cause of losses in the large reserves of mature timber that are ready for cutting. Because of the particular emphasis that has been attached to these losses—occurring as they do in timber that supports lumbering operations on both government and private holdings—the major effort of entomologists in both federal and state services

has been given over to the study of problems arising from Dendroctonus infestations. Many detailed surveys have been made in areas

FIG. 3.—Second phase of an epidemic of the Western pine beetle, *Dendroctonus brevicomis* Lec., in the Cascadel Area, Sierra National Forest. This photo was taken in July, 1931. The groups of faded trees were killed by the 1930 overwintering brood of western pine beetle. These were the nuclei from which the 1931 attacks developed. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Photo by Miller.*)

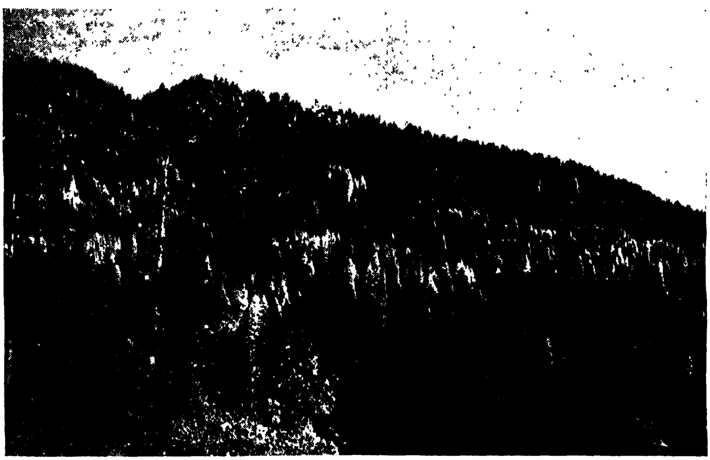

FIG. 4.—Same area as Fig. 3 but this photo was taken two and a half months later (Oct. 1931). Note the spread of the infestation from the first centers. The majority of these newly faded trees were killed by attacks of the summer broods of 1931. The colored foliage lasts for one or two seasons, then falls, and the dead trees become snags. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Photo by Miller.*)

of outstanding damage, and the extent and character of losses in certain areas have been determined with considerable accuracy. The annual drain in coniferous forests of the Rocky Mountain and Pacific

Coast regions from bark-beetle infestations has been estimated at five billion feet, with an average stumpage value of about $15,000,000.

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CHAPTER II

THE CONTROL OF FOREST INSECTS: GENERAL CONSIDERATIONS

FOREST CONDITIONS

Under natural forest conditions a very complex interrelationship exists between the potential of insect progeny on the one hand and the resistance of the environment on the other, which tends to prevent any one form from becoming overabundant for any considerable period. This law, which was first defined by Darwin, is called the "balance of nature," and if it were not for its operation the earth would soon be completely overrun by hordes of insects. As it is, an equilibrium is maintained between the organisms and their environment unless other factors disturb the balance, in which case an increase or decrease in those forms which are affected can be expected. Some of the more important factors in the environment of forest insects which play a part in determining the prevalence of different species from year to year are (1) a highly favorable food supply, which is determined by the number of decadent or weakened trees, such as overmature, defoliated, or diseased trees; by the number of trees injured by lightning, forest fires, or mechanical injury; by felled or broken trees, such as those broken by snow or winds and trees felled along roads or rights of way or left in the woods after logging operations; (2) favorable or unfavorable climatic conditions as determined by temperature, moisture, and light; and (3) natural enemies, which include parasitic insects, predacious insects and mites, birds, rodents, and diseases.

These great forces of nature play a very important part in the lives of forest insects, as well as affecting the abundance of their food supply. From the standpoint of the effect upon forest insects, the more important climatic factors are temperature, moisture, and light. These vary with altitude, latitude, longitude, and exposure; they at times produce favorable conditions for insect development and at other times become limiting factors to insect abundance.

Temperature.—Insects in general have a comparatively small range of temperature within which they are most active. For most of the temperate-zone species, temperatures between 50 and 96°F. allow the optimum of insect development and activity.

Temperatures higher or lower than this optimum range retard development and, if excessive, produce paralysis and death. For instance, bark temperatures of 115 to 120°F., which are often produced on the top sides of fallen logs, are fatal to all stages of Dendroctonus bark beetles but not necessarily fatal to hymenopterous parasites or to flatheaded and roundheaded bark borers. Cold also retards insect development, and extremely low temperatures are fatal to certain species. The western pine beetle is invariably killed when exposed to a temperature of -10°F. or less. However, in the forest it is protected by the bark of the tree in which it lives, and extremely low air temperatures must prevail before the bark temperature is brought down to the fatal point.

In 1932 the Forest Service and the Bureau of Entomology were cooperating with certain lumber companies in control projects in northern California and eastern Oregon. In December the temperature dropped to a minimum of -22°F. and stood below zero, or only a little above, for a period of at least three days. Realizing that such a long period of extremely low temperatures would probably be fatal to the overwintering brood of the western pine beetle, investigators analyzed representative samples of the bark and it was found that from 50 to 90 per cent of the larvae had been killed. In some samples the mortality was as high as 100 per cent. It was believed that these conditions insured a reasonable measure of control, and several projects were discontinued.

Moisture.—Forest insects are affected directly by moisture and indirectly by its effect upon their host. Some insects appear to be very sensitive to air humidity and the moisture content of their food material. Certain wood borers if supplied with the proper amount of moisture will complete their development in a single season, but if moisture is deficient they will take many years to complete their growth. Bark beetles appear to flourish best under conditions of relatively high temperatures and moderate humidity. Excessive drying of the inner bark is usually fatal to these beetles, or the developing broods will be small, undernourished specimens. When the bark becomes too damp or soggy with moisture, the bark-beetle larvae are unable to develop successfully and are usually smothered by the molds and fungi which develop best under such conditions.

Light.—Light has been found to play an important part in regulating the activities of various insects. Many moths are strongly attracted to it, and this tropism has been used in the development of moth traps. Shortening the hours of light even artificially will cause certain insects to pupate and prepare for hibernation. Some beetles remain inactive or refuse to lay their eggs on cloudy days but become

very active in the bright sun. Trees exposed to the full sunlight are more susceptible to attack by certain flatheaded borers. Shaded tree trunks are rarely attacked by the locust borer.

Food Supply.—The abundance or the lack of favorable food material is often an important factor in bringing about the increase or decrease of an insect species. Pure stands of certain species of trees offer more favorable conditions for insects than do mixed stands. Many forest insects are entirely capable of attacking and feeding upon healthy trees, and in such cases the abundance of food material simply implies the abundance of the host plant. Other forest insects require especially favorable conditions for their development, such as is obtained when the forest is replete with overmature or decadent trees, quantities of windfalls, snowbreaks, lightning-struck trees, or trees weakened from other causes.

Mature Timber.—Overmature, decadent, and suppressed trees usually offer susceptible material for bark-beetle attack. In such trees growth and vitality have been retarded, and they are unable to withstand beetle attacks.

Defoliated Trees.—Trees that have been stripped of their leaves by defoliating insects suffer from a retardation of growth and vitality and if not killed outright often offer suitable food material for other destructive pests. For example, a needle miner working in the needles of lodgepole pine in the Tuolumne meadows of Yosemite National Park so seriously stripped and weakened the trees that they became an easy prey to the ravages of the mountain pine beetle, and extensive stands of this pine were completely destroyed. The western pine beetle has greatly increased its damage in the ponderosa stands of southern Oregon which have been defoliated by the Pandora moth. On the other hand, lodgepole pine in Yellowstone Park defoliated by a needle tier and a sawfly was not attacked by bark beetles.

Diseased Trees.—Diseases that defoliate trees may render them susceptible to the attacks of cambium-feeding insects in the same manner as when defoliation is due to insects. Rots that attack the heartwood of trees, however, do not make them especially attractive to either wood-boring or cambium-feeding insects. Heavy mistletoe infection in pine may gradually slow down the growth, but records do not indicate that such trees are any more susceptible to bark-beetle attack than noninfested trees. Any disease, however, that causes a sudden checking of the growth of the entire tree, or a part of it, usually results in a favorable condition for the attack of secondary bark beetles, borers, etc. A blight that has recently attacked planted Monterey cypress in California has been followed by an increase in the

infestation of Phloeosinus beetles and the cypress bark moth, *Laspeyresia cupressana* Kearf.

Lightning-struck Trees.—Coniferous trees struck by lightning appear to be very attractive to bark beetles, and few trees escape death if these beetles are present in any numbers. In fact, unless lightning-struck trees are completely shattered, they rarely die unless attacked by insects. However, there are rarely enough lightning-struck trees in a forest to influence insect abundance noticeably one way or the other.

Windfall and Snowbreak.—On the other hand, wind and snow often level large areas of forest and provide great quantities of material favorable for insect breeding grounds. As a result, destructive forest insects sometimes increase greatly in numbers, and standing trees in the vicinity suffer heavily when the insects leave the fallen trees and seek other host material. A number of severe epidemics of bark beetles can be traced to wind-blown timber.

Slash.—Slash, which includes all the debris left on the ground following the cutting of trees in the woods, offers favorable breeding material for a great variety of forest insects. Most of these are species that prefer to feed upon dead or dying trees and are not particularly injurious to the living forest. But some potentially injurious species, as well as many secondary and beneficial insects, also attack and breed in slash. The tendency is for the different species to breed in the same parts of cut and fallen trees as in standing trees. Thus those species which normally attack the limbs and twigs will be found in the cut limbs and twigs which go to make up the "brush"; those which feed in the cambium of the main trunk will be found in the cambium of broken or cull logs; those which normally attack the base of trees will be found in the stumps; and those which bore into the wood of dead or dying trees will be found boring in the larger limbs and broken logs.

Freshly cut slash may attract destructive bark beetles to the vicinity where some may attack and kill near-by standing trees. The attractive influence of slash appears to be very strong at times and may result in temporarily drawing the insect population out of the adjacent forest to the neighborhood of the cutting, where green trees as well as slash are attacked. That various species of insects are attracted to slash material, whether or not they breed in it, is shown by the fact that there is often a decided increase in infestations adjacent to slashings, prior to the emergence of any of the broods from the slash material. It is probable that much of the infestation attributed to broods emerging from slash is due not to insects actually developing in the slash but to insects attracted in quantities to the

immediate neighborhood. So the most obvious menace of slash, aside from fire hazard, is its role as an attractant for harmful forest insects.

All of the most destructive species of bark beetles do breed in slash to some extent. But the seriousness of this aspect of slash is a subject about which there is considerable difference of opinion among forest entomologists. Canadian forest entomologists state that in British Columbia and other parts of Canada, aside from windfalls and fire-killed timber, saw logs and slash are the chief causes of epidemic infestations of *Dendroctonus monticolae* Hopk. and various species of *Ips*. Forest entomologists of the U. S. Bureau of Entomology and others in this country while recognizing the hazard under certain conditions do not believe that slash can be considered one of the chief causes of epidemics, since most of our worst epidemics have been in virgin areas far from any cutting operations, and in many cases cutting operations have tended to reduce near-by epidemics rather than increase them.

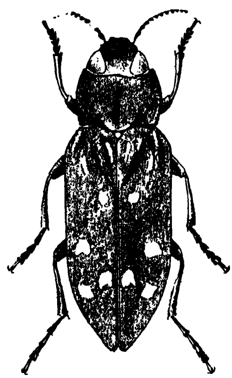

FIG. 5.—One of the flatheaded borers, *Melanophila consputa* Lec. × 3. These beetles are often attracted by burning trees or slash.

There is a tremendous difference in the success with which different species of insects breed in slash at different times and places. Species of *Ips* breed very successfully in fallen material and turn out strong broods, which may cause extensive destruction of reproduction and small trees; while under similar conditions Dendroctonus beetles usually develop broods below normal. Then, too, there is considerable difference in development, depending upon environmental factors such as moisture, heat, fungi, and other insects. Frequently conditions for brood development in slash are so poor that fewer beetles emerge than made the original attack, and the slash acts as a controlling agent.

In order to avoid any possible insect menace from slash, several things may be done. Burning the slash at the earliest opportunity may be effective in disposing of many potentially destructive bark beetles. The law in many states requires that slash be piled and burned in order to reduce the fire hazard. The usual practice is to pile the slash during the cutting operation and then burn it in the fall when moisture conditions permit the safe use of fire. This practice effectively disposes of such slash-breeding beetles as have a life cycle longer than the delay in burning—for instance, beetles with only one annual generation in cases where the slash is burned within a

few months of its creation. On the other hand, many bark beetles with short life cycles may complete a generation in the slash during the summer months when it is too hazardous to burn. During the fire-hazardous summer period, slash often can be spread or scattered over the ground, and the sun's heat used to kill many destructive beetles both through the drying effect and through the actual raising of temperatures above fatal highs.

If a logging operation is continuous during the summer months, it has been found that usually sufficient fresh slash is laid down to absorb the bulk of the emerging broods and protect the near-by standing trees, so that under such conditions no special precautions need be taken. The insects that attack felled logs are usually taken with the logs to the mill, and enough of those remaining in the cull logs and brush are destroyed by fall burning to keep the cutting area reasonably free from infestation.

Fire-weakened Timber.--A forest fire usually leaves in its wake a tremendous breeding ground for forest insects. The smell of the burning trees seems to attract certain species from far and near. One flathead borer, *Melanophila consputa* Lec., cannot even wait for the trees to cool off but flies through the smoke and deposits its eggs on the still smouldering tree trunks. It frequently causes the fire fighters considerable annoyance by pinching them viciously on the neck and hands. As soon as the trees cool off many other species of insects, including some of the more destructive bark beetles, are attracted to the fire-weakened trees where they lay their eggs. Many trees that might otherwise survive the fire injury are thus killed by the attack of the insects.

Although fire-weakened trees are very attractive to insect attack, they do not always furnish satisfactory conditions for normal brood development. When the needles are burned, transpiration from the tree ceases, and moisture taken up by the roots accumulates in the sapwood and under the bark and produces a wet "sour-sap" condition which is fatal to the broods of most bark beetles. Frequently a condition has been observed where the mortality of the developing broods has been so great as to act as a controlling factor, with fewer beetles emerging from such trees than attacked them. Because of this condition, fire-scorched areas do not necessarily breed insect epidemics to become a menace to the surrounding forest.

Neither do fires have much effect in destroying the injurious bark beetles present on an area at the time of the fire. The thick bark of the trees acts as a heat insulator to protect the beetles within. Bark on standing trees has to be severely scorched before the insects suffer any ill effects. It is obvious that a fire of such severity would kill

more trees than insects. Destructive tree-killing beetles seldom breed in the forest litter or duff, and hence ground fires or "light-burning" fires, which have at times been advocated, could be of little benefit. In the control of certain defoliators which pupate on the ground or are driven from the trees by smoke, some benefit may be derived from ground fires, but even in such cases the use of fire as a method of control is of doubtful expediency, and the benefits would probably be more than offset by harm to the young forest growth and by rendering some trees susceptible to bark-beetle attack.

Silvicultural Practices.—The successful meeting of the problem of managing forests so as to avoid insect damage depends upon a knowledge of what constitute favorable conditions for the insects, then growing and harvesting the forest so as to avoid as far as possible these conditions.

Overmature forests offer favorable conditions for certain insects. The western pine beetle shows a decided preference for slow growing timber and works great havoc in some of the old virgin stands of the west. Future pine forests should be grown on a much shorter rotation so that the trees will never reach the age of the veterans now found in the forest. Under such a system of management much of the present loss from these insects will be avoided.

The density of a forest stand is another factor which may influence its attractiveness to insects. Density not only has an influence on the temperature, air movements, and evaporation within the forest but affects the growth and competition between the trees themselves. In some cases a stand may be so dense as to result in overcrowding so that the trees will be undernourished and lack resistance to insect attack. Outbreaks of bark beetles have been known to occur in young second-growth stands of pine which had become growth-locked from overcrowding. These outbreaks have subsided as soon as the stand was thinned by the killing of some of the trees. On the other hand, open stands expose the trees to attack by sun-loving beetles which do the greatest injury to the parts of trees exposed to full sunlight.

The composition of the stand may also influence its susceptibility. In a number of cases, it is thought that pure stands have aided the insects in causing more widespread havoc than would have been the case had the forest been mixed with other species.

It is certainly true that pure stands of any species planted outside its natural environment are exposed to serious injury, if not complete extinction, by pests which have been brought in with their hosts and without their natural enemies to hold them in check. This occurred in the plantations of ponderosa pine in the Nebraska National Forest

at Halsey, Neb., where the pine tip moth became accidentally introduced without its parasite. Control was eventually established by the introduction of the parasites.

There are a great many other environmental factors in the forest which may have an influence indirectly on insect abundance and consequent damage. Overgrazing, ground fires, lack of drainage, unregulated cutting, disturbance of the animal population are all factors which may have profound and far-reaching influences. However, the interrelation of all of these environmental factors is at present only imperfectly understood, and any rules that have as yet been made are based only on theories and a limited amount of evidence. Many radical changes may be made in present-day conceptions before some of the problems are solved.

A great deal of injury by insects can be avoided if the cutting of timber is regulated so as to make conditions unsuitable for insect multiplication. Such modification of cutting practices involves selection of the trees to be cut, the avoidance of injury to those left standing, and the disposal of the refuse or slash in such a way as to destroy the breeding places of injurious bark beetles.

In selecting trees to be cut, the policy should be to remove those most susceptible to insect attack. In the ponderosa-pine forests this means taking out those trees which are growing very slowly and trees which are suppressed, diseased, or have been injured from various causes. In some forests it will mean thinning the stand so as to give the remaining crop reduced competition for plant food and moisture, thus insuring better growth. In other cases it will mean removing tree species that are particularly susceptible to insect attack in order to favor more resistant species in the second crop.

Injuries during logging to the remaining stand are very frequently points for infection of fungous diseases and for injurious forest insects. All foresters recognize the importance of reducing such injuries to the minimum.

If the breeding places of insects were continually removed or destroyed, undoubtedly a great deal of insect injury could be prevented. However, under our present extensive management of the virgin forests of the United States, very little of this forest sanitation is economically practicable. Only where extensive windfalls occur or logging operations are in progress is it practicable to carry out cleanup methods. As the forests become more intensively used, as in our national parks, around summer recreational developments, and in privately owned tracts of high value, much can be done and is already being done to keep the forests free from insect-breeding places, and in such cases the loss from insects is being held to a minimum.

NATURAL ENEMIES

Like all other animals, insects have their enemies which under normal conditions tend to hold them in check. These enemies may be other species of insects, mites, birds, rodents, or diseases. As the insect becomes abundant, its enemies, too, become more numerous, until the point is reached when the enemies overbalance their prey in numbers. They then rapidly destroy their own food supply and soon suffer from starvation. With the decline of the enemies the insects again have an opportunity to increase. These are some of the important factors in the "balance of nature."

Beneficial Insects.—There are a large number of insects belonging to different order and families which have the habit of preying on

FIG. 6.—A predacious ground beetle, *Calosoma sycophanta* L. Slightly enlarged.

FIG. 7.—A lady beetle, *Coccinella californica* Mann. × 2. Larvae and pupae on twig. (*Kellogg's American Insects.*)

other insects. When they prey on the insects that are destructive from man's point of view they are considered beneficial. In general, these insects with cannibalistic tendencies are divided into two groups: (1) predators, which quickly kill and devour their prey, and (2) parasites, which live within or on their host during some stage of its life and gradually consume it without causing the death of the host until the parasite is well-developed.

Predators.—The larvae and adults of many insects belonging to the orders of Coleoptera, Hymenoptera, Diptera, Hemiptera, and Neuroptera live on the various stages of forest insects and tend to hold them in check.

The clerids, Cleridae, are medium-sized, narrow, antlike beetles which feed voraciously on bark beetles. Both larvae and adults of

most species feed on insects which inhabit the bark and wood of forest trees and in some localities are a most important natural check on these destructive forest insects.

Some species of ground beetles, Carabidae, prey upon forest insects, usually leaf-feeding caterpillars. The genus *Calosoma* is particularly important. *C. sycophanta* L. is a very valuable enemy of the gypsy moth.

Lady beetles, Coccinellidae, are well-known as predators of scales and aphids.

Ostomids, Ostomidae, include several species of beetles which are very active enemies of bark beetles. They are predacious in both the larval and the adult stage.

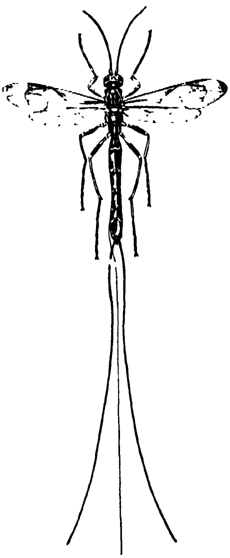

FIG. 8. Ichneumon parasite, *Megarhyssa lunator* (Fab.), of the pigeon tremex. (*Reduced. After Jordan and Kellogg, Animal Life.*)

The order Hymenoptera furnishes a few important predators, although most of the entomophagous families are parasitic. The large red wood ants, *Formica haemorrhoidalis* Emery, are very active in running over trees infested with the western pine beetle and capturing the emerging adults.

Some Diptera are predators, particularly those belonging to the families of Asilidae and Syrphidae. The asilids or robber flies are large hairy flies, sometimes resembling bumblebees; they are common in the woods and feed on other insects. The larvae of many syrphidae live on aphids and other soft-bodied insects.

The order Hemiptera also contains a number of predators. Members of the families Reduviidae, the assassin bugs, and certain Pentatomidae, the stink bugs, destroy large numbers of injurious insects each season. Their favorite food is caterpillars, and many of our very destructive forest-tree defoliators are among their victims. Burke has noted that the spined soldier bug, *Podisus maculiventris* Say, is responsible for destroying the eggs, caterpillars, and pupae of the California oak moth.

The Chrysopidae or lacewing flies of the order Neuroptera are common in the forest and feed on aphids, as do the closely allied raphidians.

The Acarina or mites are of less importance but at times are found in great numbers in the mines of scolytids, buprestids, and cerambycids where they destroy the eggs, larvae, pupae, and even the newly formed adults.

Parasites.—Parasites are entomophagous insects which enter some stage of the body of their victims and destroy them. The larval stage is the one most frequently selected, but eggs, pupae, and adults may also become parasitized. The most important parasites are found chiefly in the orders Hymenoptera and Diptera.

In the order Hymenoptera are found the great majority of the parasites of forest insects. These belong for the most part to three superfamilies, Ichneumonoidea, Chalcidoidea, and Proctotrupoidea. The Ichneumonoidea includes a large number of insects, many of them small but others medium to large size. They are well-known as parasites of lepidopterous pupae and caterpillars, as well as wood borers. The Chalcidoidea are very small wasps which parasitize a great variety of forest insects; a few of them, however, are injurious to coniferous tree seeds. The Proctotrupoidea are all minute in size and many infest the eggs of other insects and so are usually quite beneficial. A more complete discussion of the habits of the various species is given in Chap. IX, under the order Hymenoptera.

FIG. 9.—A Tachina fly, *Blepharipesa adusta* Loew. × 2.5.

In the order Diptera are some five or six families which are largely parasitic on other insects. The family Tachinidae furnishes the majority of dipterous parasites, and species are recorded as preying upon leaf-feeding beetles, clear-wing moths, all classes of defoliating caterpillars, some sawflies, and even upon a few beneficial beetles.

Birds.—Many species of birds are insectivorous and under normal conditions are probably an important factor in holding destructive forest insects under control. The woodpeckers especially are important enemies of bark beetles and borers. Beal found that, aside from sapsuckers, woodpeckers live very largely upon the larvae of wood-boring insects. The percentage of buprestids, cerambycids, and scolytids found in the stomachs of woodpeckers varied from 14 per cent in the downy woodpecker to 77 per cent in the three-toed woodpecker. Under certain conditions woodpeckers often specialize on larger forms in trees killed by bark beetles and by so doing destroy the enemies rather than the bark beetles.

Chapin has shown that from 2 to 20 per cent of the food of vireos consists of Lepidoptera. The food of starlings has been found to average about 7 per cent Lepidoptera throughout the year. Perkins lists more than a dozen birds that render valuable service by destroying

tent caterpillars, and Brunner found certain woodpeckers to be the greatest factor in holding the Zimmerman pine moth in check.

Creepers, flycatchers, nighthawks, vireos, nuthatches, and warblers consume large numbers of insect eggs, scale insects, aphids, and leaf-feeding larvae. They also destroy many hibernating insects and catch many adults on the wing. They probably feed more or less indiscriminately upon both beneficial and injurious species, taking whichever happens to be the more abundant. In doing this, while they do not control the injurious forms, they play their part in the balance of nature and help to prevent the injurious species from becoming so abundant.

Rodents.—Certain small mammals may be quite important as enemies of insects. Squirrels, shrews, and mice gather hibernating insects, especially pupae, and store them for food. Caches containing hundreds of pupae are sometimes found. Chipmunks gather the pupae of the Pandora moth from the soil and store them for winter food, immense numbers being gathered during the years when pupae are common. Graham says that mice are the most important enemies of the prepupae of the larch sawfly in the cocoons during the winter.

In control projects carried on in Idaho where the peeling of the bark is employed to expose the broods of the mountain pine beetle, studies have shown that shrews feed actively upon the larvae and pupae of the beetles and are therefore a considerable aid in supplementing this method of control.

Fungus, Bacterial and Other Diseases of Insects.—Certain fungi and bacteria attack and kill insects, and at times the diseases caused by these organisms are of considerable importance. Hewitt has shown that *Isaria farinosa* has killed a large percentage of the larvae of the larch sawfly after they had spun their cocoons. Speare and Colley during experimental work with the browntail moth larvae in Massachusetts succeeded in destroying 60 per cent of the larvae by artificially infesting them with *Entomophthora aulicae*.

Entomophthora sphaerosperma has a wide variety of hosts, being known to attack insects belonging to many different orders. As a rule, however, each species of fungus is quite restricted in its selection of hosts. It is not uncommon to find individuals or even a considerable percentage of a brood of bark beetles dead and covered with fungi. In many cases the fungus causes the death of the insects; in other cases it is saprophytic and comes in after the insects are dead. More investigations need to be made among all the groups of organisms that affect injurious insects, as our knowledge of these friends is exceedingly meager.

Bacterial diseases of insects have been but little studied, but it is known that certain bacteria are important factors in the control of some grasshoppers and other insects. Wilt disease is an infectious disease of gypsy moth and some other caterpillars which sometimes is of very great economic importance. Its causative organism is not definitely known.

Climatic conditions have much to do with the spread and effectiveness of these diseases. The greatest mortality occurs under conditions favorable to the disease and adverse to the insects. Some entomologists doubt if these diseases kill insects except when they are already weakened from other causes.

FIG. 10. -Larvae and pupae of the oak moth, *Phryganidia californica* Pack., killed by bacteria.

REMEDIAL CONTROL

The field of forest entomology is so broad and involves so many different species of insects working under such widely varying conditions that it is impossible to define many general principles regarding control. Leaf feeding, sapsucking, twig girdling, cambium mining, and root or wood boring insects may be encountered, each requiring a different type of treatment. Conditions may vary from the protection of individual shade trees where intensive methods are warranted, to the protection of park trees or small forests on recreational areas or large commercial forests extending over vast areas. It is evident, therefore, that each infestation will present many points in contrast to other infestations, so that it is always advisable to determine policies and methods to be followed only after a thorough study of the local conditions.

Certain preliminary steps are necessary before attempting control of any insect. A thorough knowledge of the life history and habits of the species involved and its relation to the host tree is of paramount importance, since this serves to reveal the weak points in the cycle of development and indicate the most logical point for attacking the insect. For example, some species may congregate in masses during a period of their development; certain measures applied at

such times will likely prove very effective in destroying large numbers with the least expenditures of time and energy. Again, a certain very simple remedy may prove effective against a recently hatched larva or nymph, whereas if this remedy be delayed a few weeks or even a few days it is no longer effective, as the insects may have become protected by entering the plant tissues or they may have developed a protective covering. Control measures thus depend upon the habit of the insect, its life cycle, and the reaction of the tree to the injury. It is only by a careful study and a thorough understanding of the various species of insects that we may hope to apply the best method of combating an insect pest.

The second most important step in any control program is to determine how many trees or how large an area is affected and what natural boundaries or barriers occur. The protection of any small group of trees is hopeless if all the neighboring trees are heavily infested and cannot be included in the control program. In the protection of park and shade trees, usually only a small number of trees are affected. But under forest conditions usually large areas are involved, and the methods used must be applicable to such conditions.

The returns to be secured from the application of control measures is a third, and very important, consideration. Park and shade trees are usually highly prized and valuable. The cost, then, of protecting them from insect injury is usually amply justified, and intensive methods are warranted. In the control of insect pests in commercial forests, more attention must be given to the economics of control. The values involved will not permit expensive insect control measures, and often damage has to be borne because the available control methods if applied would cost more than the timber saved would be worth.

It must be realized that no control methods yet discovered will completely eliminate the insects from all further consideration. The objective to be sought from control is the reestablishment of a balance between insects and their hosts. Frequently control measures secure only temporary benefits and have to be applied at more or less frequent intervals if losses are to be held to a minimum. The timber owner in the past has been led to believe that a major infestation in timber was like a smallpox epidemic—cure the cases apparent, and the epidemic will be wiped out. Unfortunately this is not the case; the forest pests like those of the orchard or garden are always present, and no amount of painstaking work accomplished one year will bring any assurance that there will not be at least a light attack the following year. We cannot hope, either now or in the future, entirely to exterminate the various species of forest insects any more

than we may expect to exterminate the Colorado potato beetle or the San Jose scale. It is, therefore, necessary for the timber owner to realize that in order to reduce to a minimum his losses from insects, he must institute some plan of sustained protection.

On many control projects final results have been more or less nullified owing to the fact that efforts to control have been abandoned as soon as distinct improvements have been obtained. In a short time the insects have again developed to dangerous numbers and caused excessive losses. Definite plans with intelligent supervision and adequate funds for continuing the work are necessary on any control project.

During the past twenty-five years control methods, usually by no means perfect, have been devised for most of the important shade-tree and forest insects. But methods for controlling some species have not yet been worked out, and many methods used at the present time for one reason or another are not entirely satisfactory. In many cases they are expensive, or the percentage of control is not so high as is desired. There is therefore need for considerably more research along lines that may in any way offer possibilities of improving existing methods or developing new ones.

THE CONTROL OF DEFOLIATORS

There is a vast army of caterpillars, sawflies, bugs, beetles, and other insects which feed externally upon the buds, leaves, twigs, branches, and even the trunks of trees. These injure the trees either by completely chewing and devouring these parts or by inserting their beaks and sucking the plant juices. The control of such pests is very different from that applicable to insects that conceal themselves under the bark or within the twigs or leaves.

There are three general groups of weapons which man may use in fighting these pests: (1) mechanical methods, such as burning, removing the bark, trapping or collecting the destructive insects; or (2) chemical methods, in which the insects are poisoned by ingesting poisons or destroyed through contact with various chemicals; and (3) biological control methods in which steps are taken to increase the parasitic or predacious enemies.

Mechanical Methods. *Hand Picking.*—Destroying the insects by hand is the most direct method of control, but this is obviously limited to small trees and to insects occurring in small numbers or congregating in large groups where they can be reached readily. The tents of the various species of tent caterpillars and fall webworms can be pruned from the trees or destroyed by torches; some of the

larger caterpillars and the galls made by the spruce aphis can be removed by hand picking; the eggs of the gypsy moth and various tussock moths can be removed by hand or painted with creosote; and the control of the white-pine weevil in young stands of pines by jarring the weevils on to a canvas or net has been recommended.

Banding.—The placing of bands or barriers around tree trunks is a method of control effective against a few types of insects, such as caterpillars which wander from one tree to another in hordes; or wingless females, such as, for example, the fall cankerworm which must climb the tree in order to deposit their eggs. This method is not a panacea for all types of insect damage, and its indiscriminate use will bring no results whatever. Moreover, to be effective bands must be watched constantly, for they are very apt to get out of repair; sticky materials become hardened; and other materials become clogged or bridged. For the types of insects for which their use is recommended the following are the most common forms of bands.

Cotton Batting.—A strip of cotton batting from 6 to 8 in. wide is placed around the tree trunk at a convenient height, and the lower edge tied tightly against the trunk. Another string is tied about the middle so that the upper half of the band turns down over the upper string to form a flange of loose cotton. This band will remain effective so long as the cotton remains fluffy, but it must be watched carefully. Burlap bands are used in the same way.

Wire Screens. Inverted funnels made of wire screening or tin may be tacked about the tree trunk. The upper edge should be fastened securely, and the lower edge should stand out from the tree 3 in. or more. Such a trap has to be watched closely, and the insects that collect under it killed. It is not effective for very small insects and has only a limited field of usefulness.

Sticky Bands.—Bands of sticky material are probably the most effective barriers that can be used. These may be either proprietary preparations such as sheets of sticky flypaper or "tree tanglefoot," or they may be homemade materials. They may prove injurious if applied directly to the tree trunk, so they should preferably be placed on a band of heavy paper. A strip of cotton should first encircle the trunk so as to fill all the cracks and crevices. Over this place a band of one-ply building tar paper about 5 in. wide, and tie it tightly to the trunk. The sticky substance should then be applied to the paper.

Even this type of band requires frequent attention, since the sticky material may become dry and hardened or covered with dust or dead insects. Either stirring the mixture or the application of fresh material will be needed to keep it effective.

Other Mechanical Methods.—Other mechanical methods for the control of defoliating insects consist of the use of traps, baited either with some attractive substance or with a strong light as an attractant. Most of such methods, however, have little to commend them and cannot be generally recommended.

The Mono Indians in California trap the caterpillars of the Pandora moth by digging trenches around the pine trees into which the caterpillars fall when they descend the trees. This is done not as a method of controlling these defoliators but to secure the caterpillars which are dried by the Indians and used as food.

The raking up and burning of litter which may be protecting destructive hibernating forms can be recommended in certain cases. But only a few injurious insects conceal themselves in such material on the ground, and so the method has only a limited applicability.

Chemical Control Methods.—The use of chemicals in the control of defoliators has been very generally adopted because of the ease with which they can be applied as sprays or dusts, the comparative cheapness of such methods, and the wholesale destruction of insects which results.

Chemicals can be used in a number of different ways. For the control of chewing insects, a stomach poison is used which is taken in with the food. This may be applied directly to the foliage or in the form of bait. For soft-bodied sucking insects contact sprays are used. These coat or clog the breathing pores, affect the nervous system, or through a caustic action on the tissues result in the death of the insects. In some cases a fumigant may be used which affects the insects' respiration.

The Stomach-poison Sprays.—The most common method of controlling leaf-chewing insects such as caterpillars, sawflies, and some leaf-eating beetles is in the application of a poison to the foliage in the form of either a dust or a spray. The poison is taken into the stomach of the insects with their food, and death results.

Lead arsenate and calcium arsenate are the materials most commonly used. These come in either powdered or paste form and can be stirred into water or mixed with Bordeaux for the preparation of a liquid spray. The powdered form is perhaps the most generally used, and besides its use in a spray it can be applied directly to the foliage as a dust.

Other poisonous substances, such as Paris green, which were commonly used in the past, have now been almost entirely replaced by the calcium or lead arsenates.

For the protection of park and shade trees these poisons are usually applied with high-powered spray machines, since the ordinary spraying outfit is inadequate to reach the tops of such trees.

In the East this method has been used in the gypsy-moth control work and in fighting the elm leaf beetle. In the West it has been used in cities and on country estates in the protection of valuable trees, particularly in California for the control of the California oak moth.

The Contact Sprays.—Contact sprays are chemicals which have a caustic or clogging effect on the insects and are particularly adapted to the control of such soft-bodied sucking insects as aphids and scales. To be effective the spray must actually cover or touch a large number of individuals. The chemicals most commonly used are (1) nicotine sulphate, (2) lime sulphur, and (3) oil emulsions. All of these are commercial products and for the most part need only to be mixed with water to be ready for use.

Nicotine sulphate is particularly recommended for the control of aphids or plant lice but is also useful in killing other soft-bodied insects. The usual commercial form comes as a 40 per cent nicotine sulphate. This may be diluted to any desired strength. The addition of about 1 oz. of soap to each gallon of spray renders it more effective, as the soap acts to give it better spread and adhesion.

About ½ pt. of 40 per cent nicotine sulphate to 50 gal. of water or 1¼ to 2½ tsp. of nicotine to 1 gal. of water is the usual dilution.

Lime-sulphur.—Lime-sulphur as prepared commercially is particularly adapted to the control of the armored scale insects such as the San Jose scale or the oyster-shell scale. It is most frequently used as a dormant or early spring spray on deciduous trees, since the concentration needed for toxicity is greater than is safe to use on trees in foliage. It has the advantage of cheapness but the disadvantage that it will discolor paint so cannot be used on trees close to buildings.

The commercial concentrate should have a density of about 30° Bé. and at this strength should be diluted at the rate of 1 part of the concentrated solution to 9 parts of water, if used as a dormant spray.

Oil Emulsions. Mineral oils are found to be very toxic to scale insects and other soft-bodied forms, but in the past the great variation in their chemical composition and the tendency of free oils to injure plant foliage have made their use unsatisfactory. Recently, however, the mineral oils have been successfully combined with vegetable oils and alkali so as to make them soluble in water, and the results that can be secured from them are much more standardized and satisfactory. Their greatest use is in the form of dormant spray for scale pests of deciduous trees, although more recently summer oils have been developed which are effective for control while the trees are in foliage. However, they should be used with caution, since conifers and some hardwood trees, particularly hard maples, are very susceptible to injury.

Since all of the preparations sold commercially are proprietary formulas, directions for their dilution and use will usually be found on the containers.

Soap Solution.—Ordinary laundry soap or fish-oil soap is frequently used for the control of plant lice when a small quantity of spray is needed and the other materials are not available. The usual dilution is 1 lb. of soap to from 5 to 8 gal. of water for summer spraying. Such sprays are rather uncertain in effectiveness and are recommended only for emergencies. The addition of nicotine sulphate, however, makes a very effective insecticide.

Dusting.—Many of the chemicals used as stomach poisons and some of the contact insecticides can be used in the form of dusts. Usually, however, dusts are not so satisfactory as sprays owing to the difficulty of securing adhesion to the foliage or reaching the insects and the impracticability of reaching to tops of tall trees, except when the dusts are released from an airplane, as will be discussed later. For the lower foliage on trees and very small trees or shrubs, a hand duster or orchard dusting machine may be used.

The following insecticides come in the dust form:

Calcium arsenate or lead arsenate are the common stomach poisons used in airplane dusting work.

Sodium fluosilicate—a general insecticide which acts as an irritant and stomach poison.

Nicotine dust—used against aphids.

Flowers of sulphur—used as a fungicide and also effective in the control of red spiders and mites. Best results are obtained when the weather is dry and warm.

Hellebore—used in the control of cutworms and sawfly larvae.

Pyrethrum—a nonpoisonous contact insecticide most frequently used in the control of household pests and on ripening fruit.

Spraying Forest Trees.—Various chemical insecticides are usually applied by means of spray pumps. For treating large shade trees or park trees high-powered machines have been developed which enable the operator to spread the insecticide to the top of the highest trees.

Such high-powered spraying machines have a limited use in forests, especially in open stands or along roads accessible to trucks. Machines developing a working pressure of 1,000 lb. have been used with hose lines from 5,000 to 6,000 ft. long. Such equipment is expensive so can be used only in protecting valuable timber from the attacks of gypsy-moth and other defoliators. Arsenate of lead with fish oil as a sticker is very commonly used.

During recent years a very practical test of applying poisonous spray to forest trees has been carried out in Yellowstone National

Park where timber along the main highways has been sprayed successfully to protect it from the ravages of various defoliators.

Airplane Dusting.—Probably the most promising method for treating defoliators over small to large areas is to be found in the use of the airplane as a means of disseminating poison dust. Although this method is comparatively new in this country, the few instances where it has been tried have given encouraging results. With proper equipment it would seem that, aside from the element of danger to the pilot, there is no reason why it should not come into more

FIG. 11.—Airplane dusting for control of the hemlock looper on Naselle River, Wash. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Photo by Keen.*)

general use for the control of forest defoliators where the benefits will justify the expense.

The first attempt in this country actually to control a forest insect by the release of an insecticide from an airplane while passing over the infested area was carried out in Ohio against the catalpa sphinx in 1921.

Since this first demonstration, several areas have been dusted from airplanes to control forest defoliators. In 1926 experiments were carried on at the gypsy-moth laboratory, and six plots of 25 acres each were dusted with from 30 to 50 lb. of lead arsenate per acre to control the gypsy moth. In the same year, an outbreak of the hemlock looper covering 715 acres of infested forest in the Peninsula Park, Wisconsin, was controlled by dusting calcium arsenate from an airplane at the rate of 20 lb. per acre. In 1927 experiments in airplane dusting were started by the Canadian government—the Dominion Entomological Branch cooperating with the Dominion Air Service and the Ontario Forestry Branch. These experiments were continued in Eastern Canada, and in 1929 two forested areas infested with

hemlock looper in the vicinity of Vancouver, British Columbia, were dusted, and the outbreak controlled.

The largest airplane dusting project yet attempted was carried out in 1931 when 5,400 acres of commercial hemlock forest in Pacific County, Washington, were covered with dusting operations to control the hemlock looper. As a result of all this experience, the methods and equipment are gradually becoming perfected and standardized.

Many types of planes have been used in the dusting work. Landplanes, hydroplanes, or landplanes mounted on floats have been selected depending upon the availability and character of landing places. In any case a high-powered machine capable of carrying from 500 to 2,000 lb. of dust and with a reserve of power is desirable, since flying must be done close to the treetops, and the danger is considerable.

A light metal hopper with sufficient capacity to carry the required load of dust is built into the fuselage. The sides are strongly sloping; the joints are made tight so as to avoid leakage of dust into the pilot's compartment; and a sliding door is arranged at the bottom so that a lever in the pilot's cockpit will open and close it at will. Inside the hopper a paddle wheel or wire agitator operated by a crank or small air propeller is mounted to keep the dust in motion and prevent lumping. When the door is opened, the dust is forced into the propeller stream and whirled into the forest below.

On account of its cheapness, calcium arsenate with approximately 40 per cent of arsenic is now most frequently used. Adhesion is not always satisfactory with this dust, particularly on dry or young foliage, but by mixing it with other dusts with better sticking qualities this weakness may be overcome in the future.

If possible, markers are used to indicate the flight lines, and the pilot guiding on these flies back and forth across the infested area spreading the dust in parallel strips. Flying at 20 to 60 ft. above the tallest trees he releases the dust at the rate of about 100 lb. in 10 or 11 sec. This will spread out in still air over a swath approximately 300 ft. wide on the ground and 150 ft. wide in the treetops. So ordinarily the flight lines have to be about 150 ft. apart. After the first strip of dust is laid, the pilot can see it on the trees and can guide his other strips accordingly.

Climatic conditions for satisfactory dusting are rather exacting. A slight wind tends to spread the dust more evenly than when it is liberated in still air, but a wind in excess of 8 or 10 m.p.h. is apt to blow the dust far to leeward and disperse it too thinly. Atmospheric humidity should be high, as better adhesion is secured when the foliage is moist than when the dust is applied to dry foliage. If the humidity is rising, there are less apt to be rising air currents so

that the dust settles into the trees more satisfactorily. Rain tends to wash most of the dust off the trees and nullify the effect of the work. However, if the dust remains on the trees for 24 hr., most of its effectiveness will have been accomplished.

The cost of the work has varied considerably. Some of the earlier experimental work in gypsy-moth control cost from $12.13 to $24.35 per acre, with an average cost of about $15.50 per acre. The Wisconsin work showed an average cost of $7.04 per acre for labor and materials for the 715 acres covered at full dosage. After many improvements in methods the cost of the Canadian work was reduced to $5.80 an acre. On the Washington project in 1931, the cost was still further reduced to $2.71 an acre. The elements of cost were as follows:

Expense items	Total	Cost per acre
Flying time at $160 per hour	$ 8,504.00	1.58
Cost of dust, 54 tons	4,751.29	0.88
Construction of loading platform	108.13	0.02
Aerial survey map	257.60	0.05
Contributed labor (estimated)	1,000.00	0.18
Total cost of dusting 5,400 acres	$14,621.02	$2.71

With more experience, it may be possible to reduce this cost still further, as the plane charges for dusting cotton fields and truck crops are now on the basis of 50 cents to $1.00 per acre. While a cost of even $1.00 per acre may seem high when applied to the protection of forest crops, it may still be a profitable investment when valuable forest areas are threatened with complete destruction by an insect epidemic and especially so in the initial stages of an outbreak when by checking the infestation in small centers a much larger area can be protected.

The results secured from airplane dusting with arsenicals have depended somewhat upon the habits of the insects. Such insects as the spruce budworm which feed within a web on the needles are much more difficult to reach than surface feeders like the hemlock looper. However, in some cases a reduction of over 90 per cent in the caterpillar population has been secured as a result of the work, and the dusted areas have been protected from what undoubtedly would have been heavy losses. As J. M. Swaine says of the Canadian work:

It may be said that in airplane dusting we have at last a weapon with which at least some of the destructive insect outbreaks of the forest may be

effectively combated, and, if improvements in poisoned dusts and the development of air machines specially adapted to this purpose keep pace with the investigations, this method of control should have a wide field of usefulness in the future.

Fumigation.—The use of fumigants such as hydrocyanic acid gas or calcium cyanide in the control of forest and shade-tree defoliators has not been used, as it has in the control of citrus-tree insects on account of the large size of the trees dealt with and the consequent expense. It is doubtful if it will ever have much of a place in this work except for the control of scales on small and particularly valuable ornamentals. Fumigation with carbon disulphide is the accepted method for the control of insects in seeds, such as seed chalcids, maggots, caterpillars, and beetle larvae in coniferous seeds and nuts, such as acorns and other large seeds. A satisfactory treatment is to place the seeds in an airtight container and use 2 oz. of carbon disulphide to each bushel, placing the carbon disulphide above the seeds, as the gas is heavier than air and settles. For large projects, use 6 lb. to each 1,000 cu. ft. of the container.

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CHAPTER III

CONTROL OF FOREST INSECTS: BARK-BEETLE CONTROL

FACTORS TO BE CONSIDERED

No practical method has yet been devised that will prevent the attack of bark beetles upon certain trees in the forest. Neither is there any way to save the trees once the attack has become established and the broods have started development. This is largely due to the habit of these beetles to concentrate upon certain trees in the forest and kill them quickly.

Even if measures of arresting bark-beetle attack in individual trees were feasible, the task of applying the remedies over large forest areas in time to save any great number of trees presents physical difficulties which could hardly be overcome, except at unwarranted expense. The only course open is to destroy the broods of beetles while they are still in the trees that have been killed and before the insects can emerge and attack other trees. This can be accomplished by any of a number of methods which will be described later. The purpose of the control work is to break down and reduce the bark-beetle population within a forest area, without regard to saving the infested trees. The lumber in the treated trees, however, may be either destroyed or salvaged, according to the method employed.

In considering control of bark-beetle infestations for a specific forest area, the owner of the timber must take into account a number of factors. There must be considered the value of the timber at stake, the seriousness of the present losses, the probability of the infestation's decreasing or increasing as determined by a study of the complex biological factors involved, and finally the chances of reducing the losses at a cost that will not exceed the actual value of the timber that can be saved by control work.

Serious losses due to bark beetles have for the most part developed in the mature coniferous forests where the values are tied up in mature stumpage ready for the harvest. The growth rate in the merchantable trees of these stands is usually so slow that it adds but little to the forest capital annually. To realize upon his investment in stumpage, the owner must turn this mature timber into lumber or other wood products before it is seriously depleted by fire, insects, or other causes. In timber of low value, it may be more economical to disregard the

toll from bark beetles where the damage is only slight or where it does not exceed the growth increment of the stand than to invest money in control measures. On the other hand, there is the possibility that a relatively light bark-beetle infestation, if allowed to run uncontrolled, may suddenly become epidemic and destroy within a few years more than half of the forest capital.

No steps taken to control a bark-beetle outbreak have much chance for success unless they are based upon sound and intimate information regarding the habits of the insect or insects responsible for the losses. The extent of the infested area and its natural boundaries, the ecological factors affecting the increase or decrease of the beetle population, and the probable future course of the infestation all enter into the consideration of a proposed control project. When control is decided upon the methods best suited to the species of insects and host trees and to the local conditions of the area must be selected.

The more important steps in dealing with an infestation of bark beetles in a tract of timber may be itemized as follows:

1. An examination or survey to secure the essential information regarding the cause, extent, and character of the infestation.
2. An analysis of the conditions shown by the survey leading to a decision regarding the advisability of control work.
3. Carrying out of a campaign of eradication measures according to a definite plan, with the purpose of reducing the beetle population to a point where timber losses are no longer serious.
4. Provision for follow-up or maintenance work in seasons following the initial control work, whenever it seems necessary to prevent the infestation from again becoming aggressive.

SURVEYS OF INFESTED AREAS

The purposes of a bark-beetle survey are: (1) to determine the species of insects that are killing the trees; (2) the distribution of the infestation, both within and bordering the area to be protected; (3) the extent and volume of recent timber losses; (4) the present status of the infestation, whether increasing or decreasing; and (5) the probable number of infested trees to be treated, if control work is undertaken.

The methods of conducting these surveys are various, depending upon the detail and accuracy of the information desired.

Without going into a systematic survey, it is possible for an observer to get a fair impression of conditions and the seriousness of an infestation by looking over an area and taking into account the proportion of dead and infested timber in the stand. However, any estimates

obtained in this way are little better than a guess, and their value depends entirely upon the experience and judgment gained by the observer in previous detailed surveys. If dependable estimates are desired, it will be necessary to cover the area by more intensive methods of reconnaissance.

Topographic Reconnaissance.—This term is applied to the methods of viewing an area from vantage points, such as ridges and lookouts, and, so far as possible, counting all trees with red and fading foliage.

FIG. 12. Barkbeetle surveys by method of topographic reconnaissance. The spotter counts and notes on a map the position of the infested trees which show white in the picture. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Photo by Miller.*)

This count, representing about two years of loss, serves as the basis for an estimate of the total number of affected trees within the area. The method can be used only in broken country where mountains or other features afford good viewpoints. Even under the most favorable conditions of visibility aided by field glasses, only a part of the recently killed trees can be seen, and the count must be multiplied by a factor of from two to five to complete the estimate. This factor can be determined by selecting a sample plot within the area that is viewed, marking all trees that can be found by intensive search, and then comparing the number of trees marked with the number counted on the sample from a viewing point. In going through the area, the estimator examines as many dead trees as he can conveniently reach, measures them, and notes the insects responsible for the killing. In this way an average can be worked out for the volume of the

infested trees and a fair record secured of the insects that compose the infestation.

The disadvantage of the topographic method is that it can be employed only in broken country when good visibility conditions prevail and that the estimates arrived at are influenced by a number of variable factors. It has the advantages, however, that it can be employed by one man working alone and that when conditions are favorable large areas can be covered very rapidly. For this reason, it is much less expensive than other methods of conducting bark-beetle surveys. To be of much value, topographic reconnaissance must be supplemented by the sample-plot or sample-strip methods which will be described next.

Sample Plot.—To employ this method, the estimator first looks over a watershed or timbered tract and then selects one or more sample areas that are as nearly as possible representative of conditions. The sample is then covered intensively, and all recently killed trees are examined and measured. The losses found on the sample are then prorated to the entire area, and the total estimate arrived at in this way.

It is important that the sample plot selected be large enough to compensate for irregular distribution of insect-killed trees within the general area. The plots selected in the ponderosa-pine type usually include a half section, but any size from 160 up to 640 acres may serve. The larger the plot the more reliable the basis for estimates, but the size is necessarily limited by costs and physical features of the area. Legal land subdivisions best serve the purpose of plots, as these can be readily identified and relocated in case future surveys are necessary.

The methods used in covering the sample plot are the same as those employed by the timber cruiser. A compass is used for orientation, the distances measured either by pacing or by chain, the location of insect-killed trees mapped, and their volume measured by taking diameter and height.

Sample-plot surveys are best run by a crew of at least three men. One member of the crew runs the compass line, keeps the distance, and maps the plot. The other men examine and measure insect-killed trees and take the necessary data. Beginning at an established corner of the plot, the crew gridirons it by running strips back and forth until 100 per cent of the ground has been covered. The width of the strips depends upon the distance at which infested trees can be detected in the stand. In open pine forests a strip 5 chains in width can be covered effectively, and in mature timber without undergrowth a four-man spotting crew can even cover a strip 10 chains in width. In heavy, dense stands, such as lodgepole pine, a strip more than 1 chain in width is seldom practicable.

When the survey of a sample plot has been completed, all recently killed trees will have been measured, marked, mapped, and the primary insects noted. For the plot itself no estimate of losses is necessary, as tabulation of the data represents conditions so far as it is possible to determine them. However, it is necessary to apply the results of the plot survey to the area as a whole, in order to arrive at a general estimate. This calls for judgment and skill on the part of the estimator, as the infestation and other conditions are seldom so uniform that a sample half section will be exactly like every other half section within the area.

The sample-plot method can be used in any area, but it is the only one suitable for heavy stands of timber where conditions for viewing are unfavorable. It is the most expensive but at the same time the most satisfactory method for obtaining current estimates of losses and of the number of infested trees on an area where control work is contemplated.

Sample Strip.—The sample strip differs from the sample plot mainly in the form of the area that is selected. Instead of being square or rectangular the strip sample is a very long and narrow plot, which is selected so as to cut across all conditions represented in the area. The methods used in covering the strip are essentially the same as those used on the plot, except that the estimator instead of running back and forth across a plot continues his strip in one direction until he has crossed the entire area.

This method is best adapted to forest areas where type conditions are not uniform, and a long strip is the only method of sampling that will cross-section all conditions. It is also best adapted to types of infestation like that of the mountain pine beetle and Black Hills beetle. These insects will form large centers of infested trees at widely separated points within a forest, and it is necessary to spread a network of strip surveys over the entire area, in order to locate these centers and secure a general average of conditions. The method is used almost entirely in the dense lodgepole pine stands of the northern Rocky Mountain region in surveys of mountain pine-beetle infestations. Here the estimators work singly, using a compass line $\frac{1}{2}$ chain in width.

In some types of country, it is feasible to use as the base line for a strip a traverse such as a road or trail instead of a compass line. This is possible only when accurate maps are available which will show location of the traverse. This sort of strip is not altogether satisfactory unless it accurately samples conditions, but where possible to use it the survey can be considerably speeded up by eliminating the compass work.

ANALYSIS OF BARK-BEETLE SURVEYS

When the survey of an infested area has been completed, the information becomes available upon which to base decision as to the advisability of control work and to formulate plans if a project is decided upon. The problems presented are complex, and hard-and-fast rules cannot be drawn which will serve in all cases as a guide to action.

First of all, the value of the timber and the necessity for its protection, as shown by the seriousness of the losses, are matters which only the owner or those responsible for the protection of public timber can decide. If conditions warrant action from this standpoint, and direct control work appears to be desirable, then it is necessary to determine whether a control project is feasible for the particular area in question and what its chances are for success. The following points should be carefully considered in the light of information made available by the survey.

Status of the Infestation.—If a bark-beetle epidemic is due to decline rapidly from natural causes, control work would be of little value. Results of past projects have shown that when treated areas are compared with nontreated areas, by far the greatest amount of timber was saved when control work was carried on against an increasing infestation, as a very large potential loss was thereby prevented. Where control work has been carried on against a declining infestation, the reduction of losses following the work has been but little more than could have been expected if natural agencies had been allowed to run their course. It is usually possible to determine whether an infestation is increasing or decreasing by comparing the losses of one generation of beetles with those of the preceding one. However, a forecast of the course of an infestation for one or more years ahead cannot be made with much assurance, as many influencing factors, such as the climatic one, are unknown quantities. Certain tendencies can be recognized, however, by the experienced observer which will give some basis for expectations. An infestation showing aggressive tendencies during one season can be expected to continue during the next. The *Dendroctonus* beetles are more or less consistent in maintaining the momentum of an epidemic, whereas the *Ips* beetles are usually sporadic. The problem of foretelling the future of a bark-beetle epidemic is a complicated one at best, and in attempting a conclusion an experienced forest entomologist should be consulted, if possible. Further research work may add to the basis for this type of forecasting.

The Control Unit.—The size of the area over which control work is to be carried on is of primary importance, as it must be large enough

to counteract the tendency of beetles to fly in from outside areas of infestation or else be completely isolated from other infestations. No results can be expected from the treatment of one square mile of infested timber if it is surrounded by similar infestation which is left untreated. Enough of the bark-beetle population must be destroyed throughout a wide area to offset the possibility of heavy invasion of beetles across the boundaries of the control area. The requirements in this respect have been found to differ according to the species of bark beetles involved.

Results of western pine-beetle projects have demonstrated that the best plan is to attempt control only when an isolated area can be selected; or, if this is lacking, to include an area of at least 15,000 to 20,000 acres; and to treat in either case all of the infested trees that can be found within the control area. The tendency of this species to invade cleaned areas does not appreciably extend more than a mile or two inside the control boundaries. With fair topographic or type boundaries, watersheds of 10,000 to 20,000 acres can be worked with success independently of adjoining watersheds with similar infestation.

The southwestern pine beetle is quite similar to the western pine beetle in its flight habits, and similar requirements for the infestation unit apply.

In the case of the mountain pine beetle, the infestation usually occurs in large mass centers of attack when epidemic. It has been found that the only successful plan is to destroy all of these large centers of infestation within a radius of 10 to 15 miles from the control area. In fact, even this distance of isolation may not be entirely effective when heavy epidemic conditions are prevalent over a wide territory. This species of beetle is attracted by the cutting and burning of trees, and where this method is used in control work, the insects may travel long distances across open areas to attack green trees left around the control operation. In the Bighole project in Montana 1926–1927, the invasion of beetles coming from distant centers to the control area was so great that more infested trees were found the season following control work than before. All the evidence indicates that this migration crossed open, nontimbered valleys in its flight. It was necessary to abandon this project because no effective barriers could be found to insure isolation.

The Black Hills beetle apparently does not travel such great distances when invading controlled areas, and the effect of the work is localized to a much greater extent than is the case with the mountain pine beetle.

METHODS OF CONTROL

When it appears that control work is desirable from the standpoint of threatened values and that a feasible control unit can be blocked out, the selection of the control method to be employed is the next consideration. There are two general types of control which may be adopted, one of which will allow for utilization of the merchantable lumber in the infested trees, while in the other case the trees are left to rot in the woods after treatment. These are: (1) to

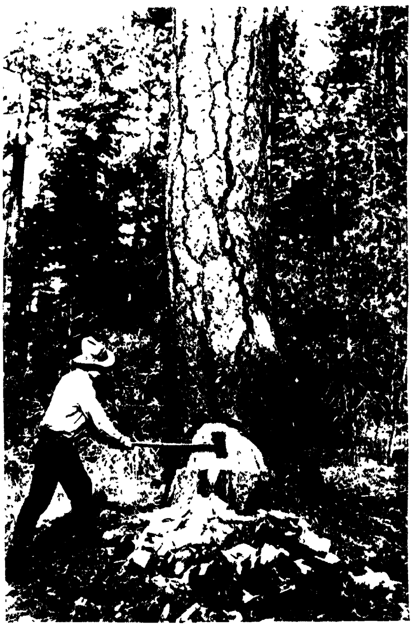

FIG. 13.—The first step in western pine beetle control felling the infested tree. The undercut shows streaks of blue stain which develops rapidly in the wood after beetle attack. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Photo by Patterson.*)

log the infested trees, remove them to a distant mill, and convert them into lumber or, if they are taken to a near-by mill, burn the slabs promptly to destroy the bark-beetle broods; and (2) to leave the trees in the woods after destroying the insects by methods such as peeling, burning, or sun-curing the infested bark.

Logging and Utilization.—Whenever possible, logging of the infested trees should be used in preference to other methods since there is the possibility of the operation's being self-supporting or even yielding a profit, and in any case a great deal of valuable lumber will be saved from total destruction. The administration of such a

project is simply a modified logging operation, with extra care being given to the disposal of slab material and slash at the correct time. This method is practical only in areas with good transportation facilities, as it is necessary to spread the cutting over a large area in a short period of time, taking only infested trees and leaving the green ones.

All infested trees should be cut while the broods are still in the trees and the slabs and slash burned before the insects emerge; or, if the logs are taken to the mill, the broods can be killed by submerging

FIG. 14. The second step in western pine beetle control—peeling infested bark from top half of log preparatory to burning. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Photo by Patterson.*)

the logs in the millpond for a period of at least six weeks. If the mill is far enough away from the forest (20 to 50 miles) no special precautions need to be taken, as the beetles will not be able to return to the forest in sufficient numbers to cause any trouble.

If, however, the infestation is in inaccessible areas of low-valued timber or widely scattered over rough mountainous country, a selective logging operation will be impractical, and artificial methods of control will need to be resorted to if the infestation is to be controlled. For this purpose the methods commonly used are either bark burning, peeling, or sun curing with various modifications. The method best suited to an area will depend upon the species of insect involved, the local conditions such as forest types and topography, and the season of the year during which the work is to be carried on.

Bark Burning.—The bark-burning method of control consists in felling the infested trees singly or in piles and scorching or charring the bark sufficiently to kill the broods in or under the bark. For groups of trees up to 20 in. in diameter, the quickest and cheapest method is to fell, skid, or buck the logs into piles and cover the butt logs with sufficient debris to insure a good burn. For thick-barked trees like ponderosa pine, treating the trees singly is usually necessary when the diameter is over 20 in., in which case the bark from the top half of the log should be peeled throughout the infested length. This

FIG. 15.—The third step in western pine beetle control—preparing the tree for burning. Note the fire line to prevent fire from spreading. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Photo by Salman.*)

bark is then piled along the log and burned. Even if the trees occur in large groups and can be treated in piles, the tops and sides of the outermost logs should be peeled to insure an effective kill. In thin-barked trees like lodgepole pine, peeling even of the top half of the log is impracticable; but because of the thin bark, burning of limbs and debris on top of the log will produce enough heat to scorch the bark effectively and kill the broods underneath.

This method is applicable to the treating of any bark-beetle infestation and is the method most widely used in bark-beetle control work on account of its cheapness and its effectiveness in disposing of the beetles and in cleaning up the slash that results from the operation. It has been used for the control not only of beetles that work in the bark but those that work between the bark and the wood. It

has, of course, certain disadvantages, the most serious of which is the fact that the burning of the bark and slash in the late spring creates an attractive influence which is apt to bring in beetles from the surrounding country and concentrate them in the vicinity of the control operations. This has been most noticeable in the case of mountain pine-beetle infestations in lodgepole pine. The fire hazard, especially in late spring work, is another serious disadvantage, and control operations often have to be halted in late spring on account of this menace.

When properly done there is very little question of the effectiveness of the burning method in killing the beetles in the treated trees. Examination of many logs treated in the ordinary course of such work on several projects has shown that fully 99 per cent of the beetles are destroyed. When control has failed to produce satisfactory results, the cause cannot be ascribed to the method of killing the beetles but to the inability of the spotters to find a high percentage of the infestation and the ability of the beetles to recuperate their losses quickly.

Burning Trees with the Aid of Fuel Oil.—One modification of the burning method, which has been extensively used in the northern Rocky Mountain region in lodgepole pine infestations, is known as "burning standing." This consists in spraying an inflammable oil on the bole of the infested tree which is then fired. The heat of the burning oil ignites the bark and the resinous pitch tubes, so that enough heat is generated to char the bark effectively and destroy the broods underneath.

The oil best adapted to the requirements is a fuel or gas oil with a gravity specification of 32 to 34 and a flash point around 160°F. The oil is thrown upon the tree from a 5-gal. pressure tank through a nozzle designed to produce a fine, solid stream. This can be thrown from the ground to a height of 30 or 40 ft. After the bole has been sprayed as high as possible, a lighted match is applied to the base of the tree, and the flames carried upward with the aid of a little additional oil. Just as the flames reach the top of the sprayed portion, more oil is thrown on at this point, and sufficient heat developed to force the fire upward through the crown.

Usually less than a gallon of oil is required to treat a tree, and, after allowing for the cost and transportation of this material, the method is cheaper than felling, limbing, and burning without the aid of oil.

The standing-burning method is not suitable to trees where the infested length extends above 50 ft. It has been modified to meet this condition by felling the tree and burning with the aid of oil while it is on the ground.

Peeling.—The peeling method consists of felling the trees across logs or other raised objects so as to hold them off the ground and then removing all the infested bark with an axe or barking "spud." In the treatment of trees where all the infested bark is within 20 ft. of the ground, the barking has been done with long-handled barking spuds without felling the tree and at considerably less cost.

This method is most applicable to the control of those bark beetles which in the immature stages work between the bark and the wood and die of exposure when the bark is removed and for the treatment of

FIG. 16.—The fourth stage of western pine beetle control—burning. The fire cleans up bark and chars the log but does not destroy it. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Photo by Patterson.*)

trees that are easily peeled. It has been extensively used in the control of the Black Hills beetle in Colorado, Utah, and Arizona and of the mountain pine beetle in sugar and white pine in California, Oregon, Idaho, and Montana. It has the important advantage of involving no risk from fire and therefore can be used during dry seasons. It is also cheaper than the burning method in the treatment of isolated trees of less than 30 in. diameter. It has the disadvantage of leaving the forest in very bad shape from the fire-hazard standpoint, as the felled trees often form a jungle of criss-crossed, "jackstrawed" logs which is almost impenetrable.

On thick-barked sugar pines and occasionally on ponderosa pine the mountain pine beetles form their pupal cells in the inner bark where they are protected. Peeling in such cases does not expose the immature stages to the air and some of the brood may complete their

development. Often the bark adheres very tightly to the trees and cannot be entirely removed, in which case some beetles escape the treatment. However, records taken on the Kaibab project in 1925 show that in the ordinary course of the peeling work 97 per cent of the broods were destroyed. This is a sufficiently high percentage to rate the method as very effective.

FIG. 17. Ponderosa pine in the Kaibab National Forest treated in the control of the Black Hills beetle. Infested trees have been felled and bark peeled. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Photo by Miller.*)

Solar Heat. A modification of the peeling method, involving the spreading of the bark where it will receive the direct rays of the sun, has been used in the control of the western pine beetle with a fair degree of success. To be effective, however, it is necessary to have an air temperature of 85°F. or more in order to produce fatal temperatures of 115 to 120°F. in the bark. Such temperatures do not always prevail during the control season, especially at high altitudes and on northern exposures, and for this reason the results have been erratic. To be effective, bark must be very carefully spread and must not be in the shadow of slabs or trees. On north slopes or in canyons it must be carried out to an opening or propped against rocks or trees, in order that the sun's rays may strike it at not less than a 45-deg. angle. The method is of value in the destruction of western pine-beetle broods during the late spring or summer or in situations where the use of the burning method would be dangerous. It may readily

be seen, however, that it is tedious, requires great attention to detail, and is therefore more expensive than either the peeling or the burning method.

FIG. 18. Solar heat control of western pine beetle. Bark is peeled from log and spread in sun where it absorbs sufficient heat to kill the broods. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Photo by Miller.*)

FIG. 19.- Lodgepole pine infested by mountain pine beetle treated by the solar heat method, Crater Lake National Park. The tree is felled and limbed so as to give full exposure of log to sun. After a few days' exposure in one position the log is rolled so as to bring the unexposed side toward the sun. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Photo by Patterson.*)

The solar-heat method may also be used without peeling of the bark if trees are felled parallel to one another instead of crisscross and are completely limbed so as to receive direct sunlight on the trunks. It is also preferable to fell the trees in a north and south direction, in order that a greater arc of the circumference may receive the sun's

heat. After a few days' exposure the logs are rolled completely over and the other half given the sun treatment.

Very effective work has been done on Crater Lake National Park in the control of the mountain pine beetle in lodgepole pine by the use of this method. During 1925 and 1926 at an elevation of from 5,000 to 6,000 ft., from May to October, with air temperatures of 80°F. or higher, an hour's exposure between 10 A.M. and 3 P.M. on sunny days was sufficient to produce fatal bark temperatures. Trees were felled and prepared and left exposed to the sun for from two to five days; then the crew returned and rolled them over. A six-man crew could prepare 80 trees per day and in one day could return and roll all those prepared in a week.

A variation in this method was employed on the Kaibab project in 1925 in the treatment of yellow pine infested with the Black Hills beetle. The trees were felled, trimmed, the upper two-thirds of the logs peeled, and the logs rolled. This avoided the extra expense and trouble of returning to roll the logs and saved some expense in peeling.

The solar-heat method is particularly applicable to the control of bark beetles, flatheaded borers, and engraver beetles, which attack thin-barked trees of small diameter, especially in open stands and in areas where the burning method is objectionable. It is most effective in southern latitudes.

This method has the advantage of being much cheaper than either the peeling or the burning method, and no attractive influences are set up by the work, as is so often the case when the logs are burned. In crowded stands it avoids the scorching of adjacent trees. The disadvantages are that considerable slash is left in the woods which must later be disposed of at considerable extra expense if the forest is to be left in good shape; also that the method cannot be used in the shade of dense stands, on cold north slopes, or in localities where the maximum air temperatures are less than 85°F., where cloudiness occurs during the control season, or when continuous strong breezes keep the logs cool.

The use of toxic oils in treating infested trees that have been felled and the use of poisons introduced into the sap of infested but still living trees are being tried out by the Bureau of Entomology, but the tests are still in the experimental stage so no recommendations are being made.

Trap Trees.—The fact that many bark beetles and wood-boring insects are attracted to felled trees suggested to some of the earlier workers the possibility of felling some of the unmerchantable trees of the forest in accessible places to act as traps to absorb the beetles and later destroying the broods by burning or peeling the bark.

This method has been tried out extensively, on both commercial and experimental control projects, but so far without marked success. Although many injurious bark beetles are attracted to the traps, they do not absorb any large proportion of the destructive beetles present on an area or prevent the attacking of healthy trees in the vicinity. Moreover, the cost of preparing and later treating the trap trees is greater than that of treating the infestation in the scattered standing ones. This method, therefore, has not yet produced results that would justify its general recommendation and adoption.

Maintenance Control.—Results of many projects, particularly those directed against the western pine beetle, have proved that the effects of artificial control are temporary and cannot be expected to keep the infestation down for more than a year or so. The building up of epidemic conditions cannot be definitely predicted, and although natural causes may combine to hold the losses down for long periods, it is sometimes good policy to carry on a certain amount of control work each year as an insurance against a return of undesirable losses. This follow-up work has been termed maintenance control and means the treating of the same area every year as long as there is an appreciable number of infested trees. From an economic viewpoint, maintenance control cannot be carried beyond a certain point, as the cost of the work per tree or board foot of infested timber increases inversely with the number of trees per timbered section. An experimental project carried out on the Sierra National Forest during the period 1920–1924 demonstrated that after the infestation has been reduced to the endemic status, natural factors influencing the increase or decrease of the western pine beetle obscured the effects of the applied work, and the reductions that could be attributed to artificial work were so slight that the saving in stumpage did not warrant the expense of this intensive work. However, in recreational areas and parks where the individual tree has a high aesthetic value considerations are materially different from those that warrant protection in commercial forests. In parks that contain any amount of virgin forest it is desirable to preserve the veteran trees, and maintenance control work, even if the results are not impressive, not only aids in holding losses to the lowest possible point but also gives some insurance against an increase of bark-beetle damage.

CONDITIONS NECESSARY TO SUCCESSFUL CONTROL

The general conclusions warranted from a study of the results of completed projects up to the present time indicate that each species of bark beetle, *Dendroctonus*, must be dealt with separately as to methods and control strategy; and that even the same species presents regional

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problems which require special plans for the management of control operations determined largely by local conditions. These conclusions as applied to the more important western species are as follows:

1. Western pine beetle, *Dendroctonus brevicomis* Lec., in ponderosa pine stands.
   a. Control work gives the best results when carried on during the fall, winter, and spring periods.
   b. In order to secure tangible results a large block of timber or a completely isolated unit must be treated in a single season.
   c. Reduction of losses ranging from 40 to 80 per cent can be expected as a result of one season of thorough work.
   d. The effects of one season's control work are temporary and cannot be depended upon to hold the infestation down for more than one to three years after the work is completed, unless natural control factors become operative.
   e. Control work carried on in advance of logging operations, where each tree saved from attack by the beetles can be milled within a few years and where it is possible to salvage the infested trees after treatment, affords the conditions under which control work is most profitable.
   f. Maintenance control work, by which is meant the continued working of the same area year after year, is profitable only under special conditions.

      Where the area is not larger than a few thousand acres and is exposed to outside infestations, maintenance control will reduce losses somewhat below that which would naturally occur but at a cost not warranted by ordinary stumpage values. However, on parks, recreational areas, etc., where aesthetic, scenic, and fire-hazard considerations make the removal of dead trees desirable and where there is an opportunity to utilize this material, maintenance control can be profitably combined with forest sanitation and utilization,

      On completely isolated areas where there is little possibility of reinfestations coming in from the outside, maintenance control is more effective and may be warranted by the protection of stumpage values only.
2. Mountain pine beetle, *Dendroctonus monticolae* Hopk.
   a. Control work carried on against this species in lodgepole pine and ponderosa pine is successful only when the main centers of infestation are destroyed and when no large centers of infestation are left anywhere within 10 to 15 miles of the control area. When the work is thoroughly done under these conditions no

serious losses may again develop on the control area for long periods.

b. Maintenance control work against this beetle has been successful in the white-pine stands of Idaho where timber was protected for stumpage values only.

c. In the sugar pine of California and Oregon this beetle does not develop the large centers of infestation that characterize its attack in other host trees in the other regions. Results of several projects directed against this particular type of infestation have indicated that control work is practicable and warranted where higher stumpage values are to be protected.

3. Black Hills beetle, *Dendroctonus ponderosae* Hopk.

Results of work carried on in ponderosa pine stands of the Rocky Mountain region and the Kaibab plateau indicate that this species responds to control in the same manner as the mountain pine beetle in the same host and in lodgepole pine. Once the heavy centers of infestation are broken down and the natural control factors become operative, the endemic condition may persist for long periods, or the infestation may apparently disappear.

4. *Ips. spp.* Various species of *Ips*, mainly *oregoni*, *confusus*, and *emarginatus*, have been included in many of the projects involved with the control of *Dendroctonus* beetles. Effects of control against these insects have not been adequately measured, but it has been found that the infestations are highly sporadic and usually spring up and die down suddenly from natural causes. Only where maintenance control is employed in the protection of specially valuable areas does it appear to be practicable to consider the control of these insects. They can be kept under control to the best advantage through methods of prevention and forest management.

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CHAPTER IV

THE CONTROL OF INSECTS INJURIOUS TO FOREST PRODUCTS

PREVENTATIVE METHODS

After trees are cut, and to some extent even before they are cut, the wood may be damaged by boring insects of various kinds. The problem then confronting the lumberman, the manufacturer, and finally the user is how to take care of his wood products in such a way as to prevent insect injury.

Before the trees are harvested, the precaution of preventing mechanical and insect injury to the trees is the only means of preventing damage to the wood. After they are cut, several precautions should be taken.

Prompt Utilization.—After trees are felled and cut into logs, they should be removed from the woods as soon as possible and made into lumber. During the period of first spring activity until cold weather starts in the fall, the freshly cut trees are apt to be attacked immediately by borers and bark beetles. Usually within a week the larvae will develop, and damage due to boring or staining the wood results. Removing the logs and placing them in the millpond will halt the work to some extent, but some activity will continue in the portion above the water line. Prompt utilization is the best means of preventing damage.

During the dormant period, from late fall to early spring, the logs are safe, and less care is needed. However, it is unwise to accumulate a large quantity of logs in the woods during this period, as it is difficult to handle them before the danger period starts in the spring, and some damage is apt to occur.

Submerging in Water.—When facilities are available the simplest method of preventing all insect damage is to place the logs in water as soon as possible after cutting. This is practical with all kinds of green woods that float, though it can be accomplished also by combining heavier woods with floaters in the same raft. Also, certain woods that do not float can be cut at such a time preceding the flight of the beetles that they will dry sufficiently to float before the danger period. "Deadening" by girdling in the fall to make floaters is also

practised for certain trees. For borer injury a longer safe period before submergence is possible, as these grubs mine beneath the bark four to six weeks before they enter the wood and consequently that long before they cause any damage. Placing the logs in water will kill all timber beetles in the wood and all borers under the bark. It will not kill borers on the top side of floating logs. It so happens that the woods that are good floaters are most subject to wormhole injury. This makes this treatment especially applicable to them. Keep floating logs in the sun to avoid injury on the top side.

Barking.—Another method to be recommended, though more expensive, is the removal of the bark from such logs as cannot be promptly utilized. Barking effectively prevents the ovipositing of nearly all of the bark- and wood-boring beetles. Care should be taken lest any bark strips be left on any of the logs or lumber, as they afford a convenient place for the ovipositing of bark- and wood-boring beetles. Barking can be done only on timbe[illegible] be used for certain purposes, as the wood checks badly.

Piling.—Where it is impossible to promptly utilize the wood or put it in water, piling in open rack or crib formation which allows free circulation of the air and insures prompt drying and seasoning will prevent the attack of many insects.

Storage.—Just as proper treatment of wood left in the forest will prevent much insect attack, proper handling of the lumber will effectively prevent much damage by such insects as feed in seasoned wood. Hopkins and Snyder's recommendations (*Farmers' Bulletin* 778) apply to the general storage of timbers: "Store so that timbers are well-ventilated; do not mix heartwood with sapwood nor freshly cut with old seasoned wood; inspect frequently and remove any infested stock; utilize oldest stock first."

Preventive Solutions.—The prevention of insect attack upon logs and timbers by spraying or dipping with chemical solutions has been experimented with to a considerable extent. Impregnation with creosote under pressure is the most effective means of preventing injury. Crude pyridine and coal-tar creosote are also recommended. Spraying or hand painting does not give good penetration, especially under bark scales and in crevices.

No satisfactory method of preventing damage to logs used in rustic work where the bark is left on has been found. The best plan is to remove the bark and then stain the wood and paint or varnish it. These substances should be so applied as to fill all the exposed wood pores and checks in which eggs of the insects might be deposited. All surface applications must be renewed from time to time to insure the filling of newly formed crevices and weather checks. After the

wood has been so treated the bark can be put in place again and nailed on, with very little danger of much future trouble.

Wood or timbers used in contact with the ground or in moist situations are very subject to the attack of borers and termites. It is essential that such timbers be given the creosote treatment before being put into place. Also, the use of very durable woods such as locust, junipers, cedars, and redwood is to be recommended where possible for such use.

TREATMENT AFTER ATTACK

Since it is not always possible to prevent forest products from being attacked by insects, and frequently considerable damage is done before the insects are discovered, often remedial methods must be resorted to.

Drying.—Insects such as the ambrosia beetles, which depend upon moisture for their successful development, can be easily killed by drying the infested wood either in the sun or in a kiln.

Water.—Submerging infested logs in water is fatal to nearly all bark beetles and wood borers, provided the submersion is continued long enough. Dormancy is the first effect of submerging, from which the insects recover if the treatment is not prolonged. Six weeks of submersion has been found to be fatal to certain bark beetles, but wood-boring grubs perhaps may live for even longer periods. Logs in millponds must be frequently turned; otherwise the exposed portions are apt to be attacked by ambrosia beetles.

Heat.—Few if any insects can survive temperatures in excess of 130°F., and many bark beetles and wood borers can be killed at 115 to 120°F. Therefore if the logs or wood products are heated until the temperature in the immediate environment of the insects reaches 130°F. and is kept there for 1½ hrs., the insects will be killed.

Steaming.—One method of securing fatal temperatures is by saturating infested wood in a kiln with live steam at a temperature of 135°F. at atmospheric pressure or higher for 1½ hr. Steaming under high pressure, however, should be avoided, as the wood is apt to be discolored and weakened structurally.

Kiln Drying.—For dry-wood insects such as the lyctus and powder-post beetles it has been found necessary in order to secure satisfactory killing effects to subject them to kiln temperatures of 180°F. or more for periods of from 2½ to 6½ hr., depending upon the thickness of the material, since they are quite able to survive the ordinary dry-kiln process. Such high temperatures are apt to weaken the wood, but under ordinary circumstances a temperature of 180°F. held for an hour should not appreciably affect it, especially if a high humidity

is maintained and no surface drying is allowed to take place. Kiln drying will not prevent the sapwood of hardwood from being subsequently attacked by lyctus beetles.

Solar Heat.—In favorable situations and with proper weather conditions, particularly in the more southern latitudes, bark beetles and wood borers can often be killed by simply exposing logs, either peeled or unpeeled, to direct sunlight. The temperature in the logs is thus raised considerably above air temperatures, in some cases as much as 60°F., and lethal temperatures are often reached. After exposure to fatal temperatures, the logs are turned, and the underside similarly exposed. It has been found that the temperature thus produced in the wood or under the bark will vary with a number of factors. The locality, latitude, condition of the sky, angle of sun's incidence, color of the bark, presence of other radiating or absorbing surfaces, air currents, and species of wood involved are all factors which may affect the success of this method and which must be considered in adapting it to any particular case.

Use of Chemicals.—When such simple remedies as excess heat, cold, moisture, or dryness cannot be used, it may be necessary to resort to chemical methods. These are usually much more expensive methods and therefore limited to the treatment of more valuable woods.

Crude orthodichlorobenzene has been found especially effective in the treatment of lyctus and other powder-post beetles in hardwoods and for the control of other insects infesting valuable finished products, rustic work, and furniture. The crude product is a colorless, stainless liquid with a slight odor but noninflammable and only slightly poisonous. However, it should be handled with care, since the odor is apt to give one a headache if breathed for an hour or so. It is usually applied full strength with a spray or saturated brush. A gallon is sufficient to treat approximately 50 sq. ft. of bark surface, and a pint is usually ample for the treatment of a chair of ordinary size. Several applications may be necessary.

Paradichlorobenzene.—This chemical is also effective and less expensive than the other. The crystals are dissolved in three parts by weight of kerosene to make a liquid which can be sprayed or painted on the wood in the same manner as described above. It is also noninflammable and only slightly poisonous.

Kerosene and Coal-tar Creosote.—Pure kerosene or a mixture of one part kerosene and one part turpentine or one part coal-tar creosote with three parts of kerosene, when applied to the wood with a saturated brush or used as a dip, is fairly effective not only in preventing attack but in killing insects already in the wood if they are not in too

deeply. Except when applied under pressure, penetration cannot be expected for more than an inch or two, and hence the treatment is fatal only to insects near the surface. The creosote-kerosene mixture should preferably be applied hot but of course should not be heated over an open fire. It should be strained through burlap before it is used.

Fumigation.—Termites, carpenter ants, and other wood borers which excavate unpacked cavities in the wood may be reached, in some cases, by fumigants.

Carbon disulphide, cyanogen gas, and chloropicrin have been used for this purpose. Carbon disulphide is injected into the wood cavities, and the opening sealed. It will penetrate to all parts of the nest not too well-protected by packed boring dust. Cyanogen gas is produced by the decomposition of potassium, sodium, or calcium cyanide and may be used in either the solid or liquid form and injected into the tunnels. Calcium cyanide in the dust form can be blown into the nest where it liberates the cyanide gas on exposure to air.

Since these are very deadly poisons, they should be used with the utmost care. *Farmers' Bulletin* 699 issued by the U.S. Department of Agriculture gives directions for handling these materials in household fumigation work.

Chloropicrin which was used in trench warfare has also been found satisfactory as a fumigant. It is very poisonous but is safer to use, since even small amounts are easily detected in the air and cause irritation to the mucous membranes.

The fumigation of woodwork and furniture in a closed room with hydrocyanic acid gas has proved successful in the control of nonsubterrean termites. The formula used was 12 oz. (avoirdupois) of sodium cyanide to 18 fl. oz. of sulphuric acid and 36 fl. oz. of water for 100 cu. ft. of air space. This killed the termites within the wood.

Burning of sulphur in a closed room is of value in killing the adults of wood-infesting insects only upon their emergence and in preventing them from egg laying.

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CHAPTER V

THE BEETLES: THE BARK BEETLES AND THE AMBROSIA BEETLES

The beetles, order Coleoptera, constitute the largest order of insects, more than 250,000 species having already been described. They perhaps are adapted to more diverse types of life and environment than are the members of any other order. Some are predacious; others are parasitic; many are plant-feeding, living on either the growing or the dead portions of plants; while still others are scavengers on animal or vegetable matter.

These insects are characterized by having a complete metamorphosis and biting mouth parts. The first pair of wings, the elytra, are hardened; the true wings when present, are folded beneath them. The prothorax is more or less movable on the hind body.

In the forests representatives of most of the families are to be found, some beneficial, others decidedly harmful. In fact, the beetles are the most important and destructive of all insects to forest and forest products. Most, but by no means all, of the injury is done by the larvae.

Only those families which have a more or less definite relationship to the trees of the forests will be considered in this work, and of these only certain representative species will be dealt with in any detail.

The bark beetles, superfamily Scolytoidea, will be considered first, as they are without question the most destructive group of insect pests to be found associated with coniferous forests. The destruction of standing timber from their activities in the United States alone has been estimated at about $62,500,000 annually. Besides killing living trees and breeding in the dying cambium of freshly felled slash, some species bore pinholes through the sapwood of green logs and seriously reduce the value of the timber. Other members of the group are secondary in their attacks; and some breed only in dead and decaying wood.

The Life Stages.—The adults are small, cylindrical, dark-brown, reddish-brown, or black beetles, ranging in size from the tiny *Crypturgus*, 1 mm. in length, up to the larger species of the genus *Dendroctonus*, which attain a length of 9.5 mm. Most species are unicolored,

either shining or dull; but a few are variegated. The elytra may be smooth or clothed with minute hairs, bristles, or scales; or they may be very rough with elevated striae. Many species have spines or tubercles on the posterior end, which may be rounded, blunt, or concave.

The head is either exposed or more or less hidden by the pronotum. The mouth parts are of the chewing type with well-developed mandibles. The labrum is absent. The antennae are elbowed at the middle and clubbed at the tip; the club usually has several segments, but sometimes these are fused as in *Chramesus* and *Polygraphus*. The abdomen is completely covered by the elytra and has five segments beneath.

The eggs are usually very small, clear or pearly white, and oval, round, or slightly elongate. They vary in size and shape with the different species and in some cases are very large in comparison with the size of the female depositing them.

The larvae are thick-bodied, always legless cylindrical and curved, white, or cream-colored, with a distinct head and prominent mandibles which are dark-colored. Spines and hairs are often present in varying numbers.

The pupae are white when first transformed but gradually take on a yellowish color as they approach the time for transformation to the adult. The antennae, mandibles, legs, and wing pads are plainly visible on full-formed pupae. Hairs and spines are often present on the various regions of the body.

General Habits.– The Scolytoidea differ from most other groups in that the adults mine beneath the bark or into the wood of plants in order to lay their eggs and so spend most of their active life out of sight. Their work is characterized usually by having both egg tunnels (made by the adults) and the larval galleries forming some particular pattern under the bark or within the wood of their host. Such patterns are distinctive for each species and often very similar for each genus.

The adults and larvae of all species bore in plant tissues, and the great majority tunnel in woody plants. Probably 90 per cent of the species attack forest trees, conifers being the preferred hosts. All parts of the trees are subject to attack. The cones, the leaves and buds, the twigs, the trunk and larger limbs, the roots, the bark, and the wood—all have their scolytid enemies.

Based upon the habits, there are three quite distinct groups within the superfamily. The largest group is known as the bark beetles. This group includes those species which mine between the bark and wood, usually engraving both. The bark of twigs, branches, trunk, and roots is attacked by various species. The second group includes

wood-eating species which mine directly into the wood and feed upon it, in both the larval and the adult stages. This group includes species of *Conophthorus*, which attack the cones, and of *Pityophthorus* and *Micracis*, which bore in the pith of twigs.

The third group, known as ambrosia beetles or timber beetles, tunnel directly into the wood of trees, making the so-called "pinholes" upon the walls of which they propagate fungi which stain the wood a dark brown or black.

The general method of attack is for the female beetle in monogamic forms, or the male in polygamic forms, to select a host and find a suitable place for starting the burrows. Some species have no trouble starting their entrance on smooth bark, but others will spend considerable time seeking a roughened area, a crevice, or a junction of branch and trunk, evidently desiring to secure a firmer foothold while starting the excavation.

The entrance tunnel is then gnawed by the parent adults through the bark, usually at a slight upward angle or nearly straight, until the wood is reached. As the work progresses, fine boring dust and excrement are extruded through the entrance hole and collect in the bark crevices; or in the case of those species which attack the cambium of living trees, pitch and sap exude from the entrance hole and harden at the surface in various forms of pitch or resin tubes. The entrance as well as the egg tunnels are slightly larger in diameter than the beetles and are perfectly cylindrical. In the polygamous forms the entrance hole is usually kept closed with the body of the male during the excavation of the egg tunnel, and he frequently dies at his post of duty, his body serving to prevent the entrance of parasites or predators.

The egg tunnels of the true bark beetles are constructed from the entrance tunnel along the surface of the wood, cutting through the inner bark and often slightly or deeply scoring the wood. With some species the tunnels are almost completely within the bark and may or may not be packed with boring dust and excrement. The egg tunnels of the wood-feeding species are completely within the wood, in the pith of twigs or in the axes of cones, and may branch in various directions or simply consist of an enlarged cavity in which the eggs are placed. The egg tunnels of the ambrosia beetles are constructed deep in the sapwood, and may be simple, branched, or compound. The compound galleries made by several genera of ambrosia beetles (*Gnathotrichus*, *Pterocyclon*, and *Trypodendron*) branch in various ways after entering the wood, and the eggs are laid in niches above and below the gallery. These are enlarged by the larvae as they develop and form pockets or "larval cradles." The tunnels of *Xyleborus* and

Anisandrus are of either the simple or branched type and consist of mines branching from the sides or ends of the egg tunnels, in which the eggs are laid and the larvae develop without constructing the larval cradles. In the case of *Xyleborus saxeseni* (Ratz.) the larvae work gregariously and eat out an enlarged leaf-shaped cavity.

So-called "ventilation tunnels" are constructed at intervals along the egg tunnels of certain species (*Dendroctonus* and *Ips*). These are perpendicular to the egg tunnel and run directly through to the surface of the bark or may end before the surface is reached. Most of these tunnels are used either as turning niches or for the disposal of frass; and later as the burrow progresses these may be plugged with boring dust. They also serve to ventilate the egg tunnel during its construction.

Egg niches are small cup-shaped cavities along the sides of the egg tunnels in which a single egg is laid. These are cut by the female concurrently with the progress of the main egg tunnel. After the egg is laid, a plug of boring dust closes the entrance to the niche in such a way that the smooth cylindrical egg tunnel is but little altered. Some species cut larger cavities and deposit from two to eight eggs in each. These are called "egg pockets." Others cut an elongate groove, termed "egg groove," on one or both sides of the egg tunnel, and deposit the eggs in layers or rows. In cave tunnels the eggs are often clustered along one side or heaped in the center of the gallery and may or may not be covered.

Turning niches are enlargements of the egg tunnel or an alcove which permits the beetles to back into them and reverse their position in the main tunnel. Frequently these are placed near the entrance and make an enlarged cavity similar to the nuptial chamber. The ventilation holes and nuptial chambers are also used for turning.

Most of the polygamous species and many of the monogamous species construct an enlarged cavity at the base of the entrance tunnel which serves as a nuptial chamber and from which one to several egg tunnels radiate or fork, the number depending upon the number of females present. The size and shape of the chamber vary with different species, and it is used not only for copulation but as a temporary storage space for the boring dust thrown out in the construction of the egg tunnels and also as a turning niche. The males of polygamous species spend all their time here and in the entrance tunnel, pushing out the borings and guarding the entrances.

Mating probably occurs most frequently in the nuptial chamber, as in *Ips* and *Pityogenes*, or near the entrance of the egg gallery, as has been observed in *Dendroctonus*, although with some species it may occur before leaving the host tree or soon after emergence. The

monogamous species possibly mate but once, while polygamous species probably copulate at intervals in the nuptial chamber during the egg-laying period.

Oviposition has but rarely been observed, because of the secluded habits of the beetles. Blackman (1915) records the following procedure: The female cuts the egg niche, backs into the tunnel, inserts the ovipositor in the niche, and deposits the egg, which seems to be coated with a sticky substance so that it will adhere to the wood. After depositing the egg the female comes out to a turning niche, reverses her position, returns to the end of the tunnel, resumes her work, and uses the borings to cover the newly laid egg. Egg laying may be completed in the first set of tunnels, or the parent adults may emerge and reattack the same or other host trees and construct a second, third, or even fourth set of tunnels. Many species have the habit of constructing one or two sets of tunnels, but in the case of *Polygraphus rufipennis* (Kirby), Simpson, working under Swaine, recorded young beetles constructing three sets of tunnels in the first season, then hibernating and constructing a fourth set of tunnels the second year. When egg laying has been completed, the parent adults usually die at the end of the egg tunnels.

The larvae and their mines are very small at first, but as the former grow the latter are increased in size and are always slightly larger than the larvae that occupy them. The larval mines start away from the egg tunnel at more or less of a right angle and may continue in an almost straight line or may turn and later run almost parallel with the egg tunnel. They are always packed with excrement and boring dust. With some species of bark beetles the mines are completely in the inner bark and are exposed when the bark is removed. Others mine for a short distance in the inner bark and then turn outward to complete their feeding and growth in the outer bark, while some feed entirely in the outer bark. The larval mines of many species are separate and distinct from one another and either make a regular symmetrical pattern or are very irregular and winding. The mines rarely cross one another, however, unless badly crowded.

With species that lay their eggs in grooves or cavities, the larvae frequently extend their borings en masse so as to form an enlarged cavity without distinct individual mines; or the mines may be contiguous at first and separate only near the end as the larvae reach nearly full growth. In the case of certain ambrosia beetles the larval mines consist only of larval cradles somewhat larger than the larva that occupies them.

Pupation occurs at the end of the larval mine in a cell constructed for the purpose. This may be in the outer bark (*Dendroctonus*

brevicomis Lec., etc.) or exposed in the inner bark (many genera); an inch or more in the wood as in the case of *Scolytus muticus* Say; or in the larval cradles or open mines of the ambrosia beetles. When the adult has become fully mature it emerges through a separate hole, called an "exit hole," gnawed by it through the bark; or, in the case of species that work en masse, many individuals may use the same exit hole. The ambrosia beetles emerge through the parent entrance tunnel.

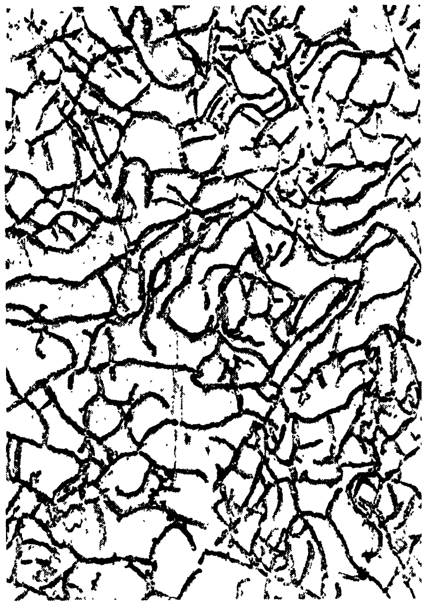

FIG. 20.—Egg tunnels of *Dendroctonus brevicomis* Lec. in inner surface of bark of ponderosa pine.

The adults may emerge at once and fly to attack new host trees or may congregate in cavities under the bark of the old host tree and hibernate (*Ips*) or wait until sexually mature before emerging. Most adults do a certain amount of feeding under the bark before emerging. A few upon emerging feed upon twigs, buds, or bark of other trees before again breeding in the bark of a new host. The food tunnels made in this way are quite distinct in character from the regular egg tunnels. Considerable food is also obtained by the adults in the process of constructing the egg tunnels, as a portion of this wood and bark fiber is passed through the alimentary canal, the remainder being pushed out through the tunnel opening or packed in the unused cavities.

Very little is known of the flight habits of the bark beetles. In polygamous forms the males often leave the old and attack the new

host before the females emerge. A few records of certain species flying in swarms have been made but it is more than likely that most species fly individually, although they do have the habit of concentrating their attacks upon certain selected host trees. Certain *Dendroctonus* have been observed flying and alighting upon a tree selected for attack more or less continuously during the warm part of the day for a period of three or four days.

Seasonal History.—Most of the members of this family complete one or more generations each year. The usual procedure is for the different broods to overwinter in the host trees attacked during the year as eggs, larvae, new or old adults. Watson (1927) found that *Ips. perturbatus* Eich. invariably overwinters as young adults, fully 90 per cent of which leave their tunnels in September and October and hibernate in decayed wood, dead leaves, and moss at a depth of two or three inches below the surface of the ground. Other species of *Ips* show a similar habit. With the advent of warm weather in the spring, activity begins. The old adults continue their egg laying, either in the extension of galleries started the year before or in newly constructed tunnels in freshly attacked trees. The new adults, usually after a little preliminary feeding, emerge from hibernation, fly, and attack other trees. Eggs, laid by new and old adults, hatch, and the larvae complete their development and emerge as new beetles later in the season. In southern latitudes several generations are usually completed in a year, while in northern latitudes and at higher elevations only one or a partial generation is completed during a season. Each species has what might be considered its normal rate of development, which is considerably modified by temperature, latitude, and altitude. The normal rate of development is discussed under the different genera and species.

TYPES OF SCOLYTID WORK

The egg tunnels and larval mines constituting the completed work of the various species of scolytids form a distinct pattern which in many cases, when the locality and host tree are taken into account, serve to identify the genus or species responsible for them.

These work patterns may be classified in a number of different ways, but the following arrangement serves to group conveniently the more typical forms:

1. Cave Tunnels.—This is probably the most primitive type of tunnel and consists of an enlarged cavity directly below the entrance tunnel, between the bark and the wood, in which the eggs are laid in groups, with or without any covering of boring dust. The larvae

upon hatching mine out individually or together simply enlarge the cavity. This type is found in certain species of *Erineosinus*, *Cryphalus*, and *Pityophthorus*.

2. **Radiate or Star-shaped Tunnels.**—These consists of an enlarged cavity and entrance or nuptial chamber under the bark directly beneath the entrance tunnel, from which separate egg tunnels radiate or branch. This type is made by polygamous species and is probably

FIG. 21. Egg tunnels branching from nuptial chambers of *Pityophthorus carmeli* Sw. on Monterey pine. Branching from the sides of some of the egg tunnels are larval mines with pupal cells at the end of some of them.

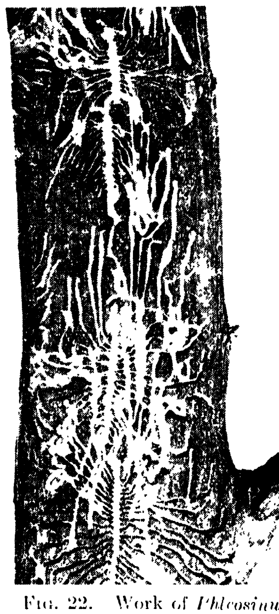

FIG. 22. Work of *Phloeosinus cupressi* Hopk. in Monterey cypress limb.

a development of the simple cave tunnel. The diverging egg tunnels may be straight or curved, longitudinal, transverse, or star-shaped and may vary in number from three to nine or more, depending on the number of females associated with a male. It is represented by the work of many genera, including *Carphoborus*, *Pityophthorus*, *Pityokteines*, *Polygraphus*, *Dryocoetes*, *Orthotomicus*, *Ips*, and others.

3. **Forked Tunnels.**—These are similar to the above except that the number of egg tunnels diverging from the central nuptial chamber

has been reduced to two. The diverging egg tunnels may be nearly opposite each other and longitudinal, transverse, or oblique; or separated from each other at almost a right angle. These are made by both bigamous and monogamous species and represent a modification of the more promiscuous forms. This type is typically illustrated by the work of some species of *Ips*, *Pseudohylesinus*, *Scolytus*, *Pseudopityophthorus*, *Leperisinus*, *Phthorophloeus*, *Phloeosinus*, and *Cryptocleptes*. *Pseudothysanoes* makes a double-forked transverse gallery which is like two forked transverse galleries joined by a short longitudinal connecting one.

4. **Simple Short Tunnels.**—These are made by the smaller monogamous species and are generally less than 6 in. in length. They may be longitudinal, transverse, or oblique and from nearly straight to slightly winding. Some have a nuptial chamber directly below the entrance tunnel, while others have no enlargement of the egg tunnel. For the most part the egg tunnels of this group are kept free from packed boring dust. This type of tunnel is well-illustrated by the work of *Phloeosinus*, *Scolytus*, *Chramesus*, *Hylurgops*, *Hylastes*, and *Alniphagus*.

5. **Elongate Irregular Tunnels.**—The tunnels of this type are made for the most part by large species of monogamous habit. They are usually more than 6 in. in length and may be longitudinal, transverse, oblique, and nearly straight to very winding and anastomose. In some species the egg tunnel is irregular in width, while in others it is uniform. The work of the genus *Dendroctonus* is typically representative of this group.

6. **Pith and Wood Tunnels.**—These may be enlarged cavities in the pith of twigs or branching mines in the sapwood, made by species that feed upon the wood, pith, or bark. They differ from the ambrosial tunnels in that they do not stain the wood. This type of work is carried on by certain species of *Pityophthorus*, *Myeloborus*, *Micracis*, *Thysanoes*, and *Lymantor*.

7. **Cone Tunnels.**—These are similar to the pith and wood tunnels and are made by species of one genus, *Conophthorus*, which burrow through the axis of immature cones, and the larvae feed upon the seeds and scales. These are monogamous in habit and are related to the twig beetles.

8. **Simple Ambrosial Tunnels.**—The ambrosia beetles cut their tunnels directly into the wood, and the ambrosial fungus stains it a dark brown or black. The most simple form of tunnel is an enlarged gallery in the wood in which the larvae live free and feed upon the fungus. The work of *Xyleborus saxeseni* (Ratz.) is a typical example of this type.

9. **Branched Ambrosial Tunnels.**—In the branched type of ambrosial tunnel the larvae do not excavate individual cradles but live free in certain tunnels. The branches may extend circumferentially with the growth rings or may radiate through the wood without reference to these. This type of gallery is made by many *Xyleborus* and *Anisandrus*.

10. **Compound Ambrosial Tunnels.**—In this type the egg tunnels branch after entering the wood usually following the rings of growth, and the larvae construct pockets or cradles above and below the egg tunnels in which they live and feed upon the ambrosial fungus. The work of *Pterocyclon*, *Trypodendron*, and *Gnathotrichus* is characteristic of this type.

FIG. 23. Egg tunnels of ambrosia beetle, *Pterocyclon scutellare* Lec., in live oak, *Q. agrifolia*. About ½ natural size.

In some cases all the species of a genus may excavate the same type of gallery, but frequently this is not the case, and the genus may be represented by several types of work.

The mating habits of some species are revealed by the type of gallery; for the monogamous species the egg tunnel is usually a single mine, while among the polygamous species there is often a central nuptial chamber from which radiate several egg tunnels. Cave tunnels may be made by either monogamic or polygamic species.

CHARACTER OF THE HOST PLANTS

Most of the members of this family are very discriminating in their selection of a host. Usually the members of a genus are confined to plants or trees of close phylogenetic relationship. In general, those species which attack coniferous trees are never found in hardwood, and vice versa. Certain genera confine their work to the pine; others to firs, spruces, or cypress-like trees. Some species are limited to only one species of tree, while others may attack any available species of several genera. The latter are found more commonly among the ambrosia-feeding beetles which live on the fungi rather than upon the wood itself.

Not only are they particular as to the species of host, but there is usually a certain part of the tree—cone, twig, limb, trunk, bark, or wood,—which they favor for attack. In many cases the thickness of the bark may be a deciding factor. They are also very particular

as to the physiological condition of the host. Certain species seem to prefer only fresh, living cambium; others are attracted by dying bark; while still others attack only dead bark or wood. Moisture, too, is a determining factor for certain species, and an excess or deficiency of moisture in the host will render it unsuitable for attack.

Many species of bark beetles attack and kill perfectly healthy trees or parts of trees, but the majority breed in dying and recently dead trees or in slash, fallen timber, stumps, and trees weakened by fire, lightning, snows, wind, and other causes. Species of primary economic importance are those which kill living timber or seriously injure the wood; while the others cause little or no economic loss or may even be a benefit by attacking and killing the lower branches of coniferous trees, helping to hasten the natural pruning process and thus producing lumber freer from knots or, through their work on slash, hastening its decay and its return to the soil. Sometimes, however, the species of minor importance may, under certain conditions, cause serious damage to living timber.

The tree, or that part of it attacked by the beetles, is killed by the galleries of either the adults or the larvae traversing the cambium and cutting off the flow of sap. In this work they are accompanied by various yeasts and fungi, which cause fermentation of the sap and bluing of the wood and probably serve to hasten the tree's death. The species, which are successful in attacking and overcoming living timber, must attack in large numbers, as otherwise a vigorous tree will overcome the insects with its sap flow.

DISTRIBUTION

The superfamily Scolytoidea is represented in every region of the world where woody plants grow. The family Platypodidae has a wide range through the tropics, subtropics, and temperate regions. In the family Scolytidae, the subfamily Scolytinae is found throughout the Palaearctic and Nearctic regions, with the largest number of species running through the subtropical and tropical regions of Central and South America; the subfamily Hylesininae is widely distributed throughout the regions of tree growth; the subfamily Micracinae is probably most abundant in Austral North America and in the subtropics; and the subfamily Ipinae is primarily distributed through the Holarctic region, where they are associated with coniferous trees.

CLASSIFICATION

Members of the superfamily Scolytoidea are distinguished from other weevils of the Rhynchophora and all other beetles by having

the beak very short or indistinct, the submentum not strongly produced behind, the antennae geniculate and clavate, the tarsi five segmented, the maxillary palpi rigid, and the tibiae usually serrate. There have been many different groupings of the superfamily into families and subfamilies, but that most favored at present divides them into two families—Platypodidae and Scolytidae.

The family Platypodidae is distinguished by having the tarsi with segment 1 as long as the others united and is represented in America north of Mexico by only one genus of pinhole borers.

The family Scolytidae includes the majority of the bark and timber beetles. It is characterized by having the first segment of the tarsi much shorter than the others united. The genera found in the United States have been grouped in four subfamilies—the Scolytinae, the Hylesininae, the Micracinae, and the Ipinae (Swaine, 1918).

The subfamily Scolytinae is characterized by having the anterior tibiae produced into a distinct process at the outer apical angle. It is represented in the United States by six genera of bark beetles, only one of which, *Scolytus*, is of economic importance.

The subfamily Hylesininae is characterized by having the anterior tibae not strongly produced at the outer apical angle, the head visible from above, and the pronotum rarely more strongly roughened in front. The group comprises about twenty genera in America north of Mexico including the genus *Dendroctonus* containing some of the most destructive species of forest tree-killing beetles; the genera *Phloeosinus*, *Pseudohylesinus*, *Hylurgops*, *Hylastes*, and *Leperisinus;* as well as many other genera of beetles of less economic importance.

The subfamily Micracinae is characterized by having the outer anterior tibiae entire or nearly so, with the sides subparallel, with the distal end squarely to obliquely truncate on the outer half and armed with from two to five submarginal teeth, and the inner distal angle prolonged to form a moderately strong terminal mucro. The group is represented in the United States by the genus *Micracis* and five other genera of small bark- and wood-boring beetles, mostly found in the southern states. Since they work for the most part in dead or dying wood they cannot be considered of great economic importance.

The subfamily Ipinae is characterized by having the anterior tibiae widened distally and serrate on the outer margin, the antennal funicle with from one to five segments, the head subglobose and retracted into the pronotum so as not to be visible from above, and the pronotum very asperate or roughened anteriorly on the disk. This is the largest group of scolytids in the United States and is represented by thirty-three genera and more than 250 species, some of which are primary enemies of forest and shade trees.

From the standpoint of the forester the scolytid bark beetles can best be grouped according to the manner in which they work upon the trees. Thus there are three main subdivisions, the bark beetles, which work under the bark of the main trunk or larger limbs; the twig and cone beetles, which work under the bark or in the pith of the smaller limbs and twigs; and the ambrosia or timber beetles, which penetrate deeply into the wood. In the following discussion the genera of scolytids are arranged according to these main subdivisions and under each in the order of importance but the species in each genus are not so arranged.

THE BARK BEETLES

By far the largest group of scolytids come within the group referred to as bark beetles, which, as the name implies, excavate their galleries in the inner bark surfaces of the cambium region. Here the parent adults deposit their eggs, and the larvae upon hatching work out into the bark, feeding upon the succulent tissues until they are full grown. The wood is not entered, except superficially, and the work tends to loosen the bark from the sapwood.

Practically all are tree pests, but the majority are secondary in their attack, and relatively few are primary tree killers.

Bark Beetles Attacking Coniferous Trees

The genus *Dendroctonus* is by far the most destructive genus of bark beetles attacking the coniferous forest trees in North America, where it is represented by twenty-four of the twenty-five known species. The enormous amount of damage done by the species of the genus in the United States is hardly to be overestimated but probably averages 20 million dollars each year.

The adults are stout, cylindrical, dark reddish-brown to black bark beetles varying from 2.2 to 9.5 mm. in length. The eggs are white, shining, and slightly oblong. The larvae are white or yellowish-white, stout and cylindrical, legless, and somewhat wrinkled and curved. The pupae have the form and size of the adult but are white with the legs and wing pads folded under the body, exposing the abdominal segments. All species of the genus will breed in living and dying bark of stumps or logs and in dying and weakened trees. Many attack and kill living trees. Some species prefer weak, dead, or dying hosts and are usually secondary bark beetles; while others apparently prefer normal, healthy trees. The evidence of attack consists of pitch tubes with reddish boring dust on the trunk or loose dust in the crevices of the bark, fading of the foliage, and egg tunnels between bark and wood.

In general, the broods hibernate in or beneath the bark in the stages of eggs, larvae, young or old adults. As soon as the sap starts in the spring, activity begins. The old adults start new galleries or extend the old ones. The young adults mature and leave the trees. The young larvae continue their mines, finish their growth, and pupate; while the old larvae pupate at once. New trees are attacked during the spring, summer, and fall, and the life-history cycle is repeated. Most of the species have one generation per year, some one and a partial second, while other species in more southern latitudes have from two to five generations a year.

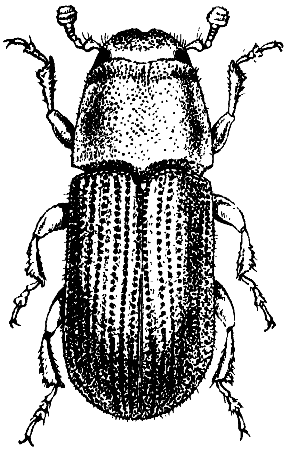

FIG. 24. Western pine beetle, *Dendroctonus brevicomis* Lec. × 12.

The hosts attacked are confined to pines, spruces, larch, and *Pseudotsuga;* the genus is distributed over America north of Guatemala, and one species is found in northern Europe.

They are preyed upon by several species of hymenopterous parasites, but these do not appear to be so important in controlling the beetles as various predators belonging to the families Cleridae and Ostomidae. These at times appear to be very effective in holding the bark beetles under control.

The methods of artificial control are dealt with in the chapter on control.

The western pine beetle, *Dendroctonus brevicomis* Lec., is one of the most destructive species of the genus. The value of timber killed by it in California alone amounts to a million dollars annually (Keen, 1928).

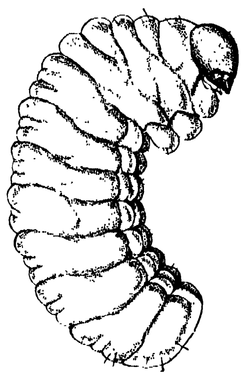

FIG. 25. Larva of western pine beetle. × 12.

The adults are dark brown to black, from 3 to 5 mm. in length. The larvae are similar to other scolytid larvae and are found in the outer corky bark of dying trees, where they pupate and change to adults, each adult leaving the tree through a separate exit hole. From one to three generations are produced a year, depending upon latitude and altitude. The species is very easily recognized by its work, which consists of winding, crisscrossing egg galleries between bark and wood, with very little of the larval mines showing on the

inner surface of the bark. It commonly attacks ponderosa and Coulter pine and in rare instances attacks lodgepole and possibly sugar pine. The species is distributed through the range of its host trees in

FIG. 26.—Ponderosa pine attacked by western pine beetle, *Dendroctonus brevicomis* Lec. A small square of paper has been pinned at each point where a pair of beetles entered the outer bark of the tree. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Photo by Miller.*)

California northward to British Columbia and eastward as far as Montana.

The southwestern pine beetle, *Dendroctonus barberi* Hopk., is the southwestern phase of *D. brevicomis*. It is found attacking *Pinus*

ponderosa and sometimes *P. edulis* in the southern Rocky Mountain region but is usually a secondary enemy, only rarely becoming aggressive like its relative farther west. The work and life history are similar to those of *D. brevicomis.*

The roundheaded pine beetle, *D. convexifrons* Hopk., 4 to 6 mm. long, very dark shiny brown to black, occurs in the same region as the last and very often in company with it, working only in ponderosa pine. The egg galleries are mostly vertical, long, and from slightly to markedly sinuous and sometimes branched. The larval galleries are usually in the cambium, and pupation may take place either exposed in the inner bark or in the outer corky bark. The species is usually secondary and relatively unimportant.

The southern pine beetle, *D. frontalis* Zimm., is a small species 2.2 to 4 mm. in length, which in work and habits greatly resembles the western pine beetle. It is a very aggressive species in the Southeast, from New Jersey and Pennsylvania south to Florida and west to Texas and Oklahoma, where it attacks the various species of southern pines. Epidemics occur at intervals, with their accompanying heavy loss of old and second-growth trees; then the beetles disappear for an interval of years, and it is difficult to find a single specimen. There are from three to five generations per year, so that the species is capable of more destruction in a given time than is almost any other of our bark beetles. This species rarely breeds in slash or down timber. Drought is extremely favorable to them, since it cuts down the vitality of the host. On the other hand, heavy rainfall restores tree vigor and tends to eliminate outbreaks.

The Arizona pine beetle, *D. arizonicus* Hopk., is a somewhat elongate dark-brown to black beetle 4 to 5 mm. in length, which attacks the Arizona pine and the ponderosa pine in the Southwest. Its work and habits are similar to those of the southwestern pine beetle.

The Colorado pine beetle, *D. approximatus* Dietz, is from 4 to 7.4 mm. in length, dark brown, and elongate; excavates irregular slightly winding longitudinal and sometimes transverse galleries between bark and wood of dying, felled, or occasionally healthy trees. The work is characterized by the absence of exposed larval mines on the inner surface of the bark. There is only one generation annually. It breeds in *Pinus scopulorum, P. arizonica,* and *P. leiophylla* from central Colorado and southern Utah south into New Mexico and Arizona but is not an aggressive species.

The mountain pine beetle, *D. monticolae* Hopk.—The adult is a stout black cylindrical bark beetle 3.7 to 6.4 mm. in length, having the head broad without frontal groove and the prothorax slightly narrowed toward the head. The beetles excavate very long, nearly

straight to slightly winding egg galleries through the inner living bark and engrave both bark and wood. The eggs are placed singly in cells which are more or less grouped on alternate sides of the egg gallery. The larval mines are exposed in the inner bark, and the pupal cells are usually exposed when the bark is removed. Emergence of over-wintered larvae occurs in late June and July, and there is usually one and a partial second generation each year. This species is tremendously destructive to lodgepole pine, sugar pine, ponderosa pine, white-bark

FIG. 27.

FIG. 28.

FIG. 27.—Work of mountain pine beetle, *Dendroctonus monticolae* Hopk., in the sapwood of a small ponderosa pine. (*Photo by Keen.*)

FIG. 28.—Sugar pine top-killed by the mountain pine beetle, *Dendroctonus monticolae* Hopk., in Yosemite National Park. The attacks in sugar pines usually start near the top and work downward until they reach the base. Two years are often required to completely kill the tree. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Photo by Miller.*)

pine and western white pine and has also been recorded from foxtail pine and Engelmann spruce. In various places in the West it

has wiped out thousands of acres of lodgepole stands. It is distributed through the high mountains of California, northward to British Columbia, and eastward to Montana and Wyoming.

The Black Hills beetle, *D. ponderosae* Hopk., replaces *D. monticolae* in the southern Rocky Mountains. Periodically it becomes epidemic and sweeps through the Rocky Mountain ponderosa stands, killing as much as 50 per cent over large areas. It also attacks lodgepole pine, limber pine, piñon pine, Mexican white pine, and Engelmann

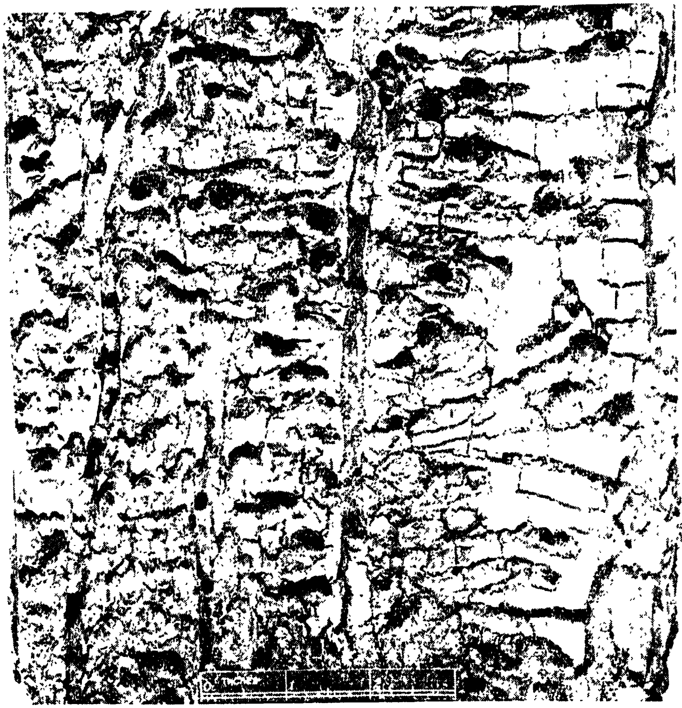

FIG. 29. Work of Jeffrey pine beetle, *Dendroctonus jeffreyi* Hopk., in inner bark of ponderosa pine.

spruce and is distributed from South Dakota south through the Rockies into New Mexico and Arizona.

The Jeffrey pine beetle, *D. jeffreyi* Hopk., is black, 6 to 8 mm. long, and attacks healthy, injured, or weakened Jeffrey pine through the range of this host tree in California. Its work and seasonal history are very similar to those of the mountain pine beetle. At times it is quite destructive.

The Douglas fir beetle, *D. pseudotsugae* Hopk.—The adults are reddish to blackish-brown bark beetles 4 to 7 mm. in length and

covered with long hairs. The work consists of vertical, usually straight or only slightly sinuous egg galleries, varying in length from 6 to 30 in., the majority being 12 to 14 in. long and from ¼ to almost ⅜ in. broad, with the eggs deposited in masses of from ten to thirty-two in grooves at alternate intervals along the sides. The larval mines run at more or less of a right angle from the egg gallery but diverge and expand as the larvae grow, so that the completed work is fan-shaped. These larval mines are often tortuous and may cross and recross one another. The engraving is mostly in the bark but may score the wood, and the pupal cells may be exposed in the inner bark or concealed in it, depending upon the thickness of the bark. There is one and a partial second generation each year. This species prefers felled, injured, or weakened Douglas fir but will also attack western larch and big-cone spruce. It is widely distributed through the forests of the western states and Canada but causes the greatest damage on the drier sites of the interior. In the moist coast forests of the Douglas-fir region this beetle is only occasionally a serious tree killer.

The eastern larch beetle, *D. simplex* Lec., is a closely related species which attacks logs, stumps, and felled and weakened trees of *Larix laricina* in the Northeast and Lake states but is usually not a serious pest.

The Engelmann spruce beetle, *D. engelmanni* Hopk.—The adults are reddish-brown to black bark beetles, 5 to 7 mm. in length, the body sparsely clothed with long hairs. They excavate a short, nearly straight longitudinal egg gallery in the inner bark, slightly scoring the wood. The gallery is excavated much wider than the beetle and is packed with boring dust, through which the adults keep open a passageway. Eggs are laid side by side in elongate cavities alternating from side to side of the egg gallery. The larvae at first bore out en masse transversely from the egg gallery but later make separate mines. The pupal cells are usually constructed in the inner bark so as to be exposed when the bark is removed but may be made more deeply in the inner bark and quite concealed. Attacks are made during June and July, and there is one complete generation annually with considerable overlapping of broods. This species has caused widespread destruction of mature Engelmann spruce through the Rocky Mountain region from Mexico to Canada and westward into Oregon.

The eastern spruce beetle, *D. piceaperda* Hopk., is similar in appearance and habits. It has caused an enormous loss of mature spruce timber in the northeastern portion of the United States, the Lake States, and eastern Canada.

The Alaska spruce beetle, *D. borealis* Hopk., is another similar species which attacks white and Engelmann spruce in Alaska and northwestern Canada.

The Sitka spruce beetle, *D. obesus* (Mann.), attacks Sitka spruce in British Columbia, Washington, and Oregon but is not always particularly destructive. It has habits similar to those of the others of this group.

FIG. 30.—Pitch tubes and castings made by the red turpentine beetle, *Dendroctonus valens* Lec., at base of Monterey pine.

The lodgepole pine beetle, *D. murrayanae* Hopk., is a stout cylindrical bark beetle 5.4 to 6.5 mm. in length, with dark-brown or black prothorax and reddish elytra. The egg gallery is like that of the Engelmann spruce beetle, but the larvae feed out en masse instead of making separate mines. It attacks lodgepole pine in the northern Rocky Mountain region but is not an aggressive enemy, usually attacking old or weakened trees at the base.

The Arctic spruce beetle, *D. johanseni* Sw., is closely related to the above. It has been found working at the base of white spruce trees in the Northwest Territory of Canada and in Alaska.

D. rufipennis (Kirby) and *D. punctatus* Lec. are other eastern species of this group. The former working in fallen white pine, jack pine, and red pine in northern Ontario requires two years for its life cycle (Watson, 1931).

The red turpentine beetle, *D. valens* Lec., is the largest species of this genus, measuring 5.7 to 9.5 mm. in length, has a more reddish color than any of the other species, a stout body, and broad head without frontal groove. The adults attack the base of living healthy, dying, injured, or felled trees and stumps, where they excavate an

FIG. 31.—Larvae and pupae of red turpentine beetle, *Dendroctonus valens* Lec., in inner bark of Monterey pine. About natural size.

irregular longitudinal egg gallery. The gallery may be only a few inches in length or several feet. Patterson reports finding one gallery extending underground following a root for 15 ft. from the point of entrance. The gallery is more or less packed with frass, and the eggs are laid in masses along the sides. The larvae feed out through the inner bark in mass formation, causing a cavity between bark and wood. Pupation occurs at the end of the larval excavations in a cell in the boring dust, and the adults emerge through the bark. This species is distributed throughout the forested regions of North America, where it attacks all species of pines and occasionally spruce and larch. Ordinarily it is not considered an aggressive pine killer, although it may do considerable damage to trees and weaken them so that they are more susceptible to other bark beetle attack. In

the case of Monterey pine in California, however, it is an aggressive and primary tree destroyer. There are from one to two or more generations annually, depending upon the locality, with a great deal of overlapping of broods. In the more southern range all stages of the beetles may be found at nearly any season of the year.

The black turpentine beetle, *D. terebrans* (Oliv.), has similar habits and does similar work in the Southeast and Atlantic states, where it attacks most species of pines.

The Pine Engraver Beetles.—The bark beetles of the genus *Ips* DeGeer (*Tomicus* Latr.) rank next to *Dendroctonus* in point of destructiveness to forest trees, particularly the pines and spruces. Occasionally they attack the firs. They are primarily enemies of young trees and the tops of older ones, while *Dendroctonus* is more destructive to mature trees. With the removal of the virgin forests it is quite likely that this genus will rank first in order of destructiveness to the second-growth stands.

Their normal habit is to feed on the cambium of recently felled coniferous trees, and they breed very readily and in large numbers in such material as windfalls, snowbreak, logging, and road slash. After increasing their numbers in such material they frequently emerge in large numbers and kill adjacent groups of young pines and the tops of older trees. Usually, however, such sporadic killings of living trees are of short duration, and after one season the beetles, much reduced in numbers, are forced to return to their diet of freshly felled logs.

The adults are medium-sized reddish-brown to black shiny cylindrical bark beetles which are easily recognized even by the layman on account of having a very pronounced concavity on the posterior end, margined with from three to six pairs of stout spines.

Like most bark beetles, the adults bore between the bark and wood and construct egg galleries along which the eggs are laid. The male beetle starts the attack and on reaching the cambium constructs an entrance or nuptial chamber. Several females then join in the work, and each constructs an egg gallery, free from packed boring dust, radiating from the nuptial chamber, cutting through the inner bark, and slightly scoring the sapwood. Eggs are laid in niches along the sides of the egg galleries, and the larvae upon hatching mine outward from it at more or less right angles and in the inner bark. Typical galleries of most species have from two to five egg galleries branching longitudinally from the central nuptial chamber like tines of a fork or Y-shaped.

The external evidence of their work is characterized by boring dust in crevices of the bark which is usually dry and free from pitch

and the absence of any conspicuous pitch tubes at the entrance to their burrows, except in cases where very vigorous trees are attacked.

The beetles usually spend the winter in the adult stage under the bark of standing trees killed the previous year or drop to the ground and hibernate under bark scabs at the base of the tree. Some species congregate in large groups and feed to a limited extent on the dry dead inner bark before emerging. With the coming of warm weather in the spring they emerge and attack fallen trees and the limbs and tops of green trees, lay eggs, and quickly hatch another brood. From one to five generations develop during the summer, depending upon the altitude, latitude, and species, with two generations most common. Ordinarily from the time of an attack until the first of the new brood emerges requires from 42 to 68 days. There is considerable overlapping of the various generations. The methods of control are the same as for the western pine beetle. Although peeling the bark will kill the immature stages, there are usually so many adults under the bark and in the limbs that burning is by far the quickest, cheapest, and most efficient method of destroying the broods.

The Sitka spruce engraver, *I. concinnus* (Mann.), breeds in Sitka spruce, *Picea sitchensis*, along the coast of Oregon and north to Alaska, attacking the partly living bark of injured, dying, and felled trees. The adults are about 4 mm. in length, with one very prominent and two smaller teeth on each side of the margin of the declivity. They excavate an irregular central nuptial chamber with three or four short, curved galleries issuing from it. Three or four eggs are laid in each egg niche. *I. chamberlini* Sw. is a similar species found in Douglas fir in Oregon.

The Monterey pine engraver, *I. radiatae* Hopk., is another similar species which attacks living injured, dying, and recently felled Monterey pine, Bishop, knobcone, lodgepole, Jeffrey, and white-bark pine from central California north to British Columbia and east to Idaho and Wyoming. The primary tunnels are curved or S-shaped, with three or four larval mines issuing from each egg pocket, since four eggs are usually laid in each niche.

The coarse writing engraver, *I. calligraphus* (Germ.), light reddish brown to black, from 4 to 6 mm. in length, is readily recognized by having six pairs of teeth on the margin of the elytral declivity. It is a very common species, distributed throughout the eastern United States and Canada, where it breeds under the thick bark of the trunk of various species of pines. It prefers to breed in the trunks of freshly felled trees and logs but will also attack living trees, in which case prominent pitch tubes form. The typical excavations have from three to five egg galleries issuing longitudinally from a central entrance

chamber and are a foot or more in combined length. The larval mines are usually from 2½ to 3 in. long, rather broad, and more or less tortuous.

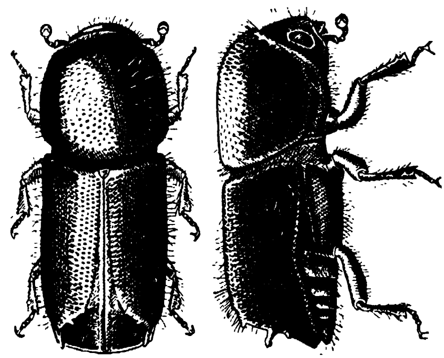

FIG. 32.—The Monterey pine engraver, *Ips radiatae* Hopk. Male, left, female, right. × 9. (*Trimble.*)

The western six-spined engraver, *I. ponderosae* Sw., closely related to the above, is a reddish-brown to black bark beetle in the adult stage, from 6.5 to 7 mm. in length, and with six pairs of spines on the margin of the elytral declivity. It is usually a secondary

FIG. 33. Work of *Ips radiatae* Hopk. in bark of Monterey pine.

enemy of ponderosa pine in Arizona, California, and Montana, attacking for the most part trees that have been felled or those dying from attacks of more primary species of bark beetles or from other causes. The work is very similar to that of its eastern relative, with usually four egg galleries issuing from a central nuptial chamber.

The southern pine engraver, *I. grandicollis* (Eich.) (*I. cacographus* (Lec.)), is a very common species found breeding in the inner bark of the trunk or limbs of various pines in the southeastern and eastern portion of the country. This species seems to prefer the trunks of saplings and the tops of larger trees and is commonly found breeding

in felled or broken material. The work consists of from three to five egg galleries radiating in a longitudinal direction from a central nuptial chamber, similar to that of many of this group. In combination with other bark beetles they are soon able to kill weakened trees.

I. chagnoni Sw. is very closely related to *grandicollis* but is larger, 4 to 4.8 mm. long, stouter, and more coarsely sculptured. It attacks white spruce and red and white pine in eastern Canada and southward into New York.

The California five-spined engraver, *I. confusus* (Lec.), is a very destructive species to tops of mature trees, small poles, and reproduction of various pines. The adults are reddish-brown to piceous black, 4 to 4.5 mm. in length, with five pairs of spines on the margin of the elytral declivity. It commonly attacks ponderosa pine and sugar pine but probably also attacks all the pines within its range, which extends from southern California north to Oregon west of the Cascade and Sierra ranges. The egg galleries radiate from the central nuptial chamber in a longitudinal direction, with from one to five from each chamber. The typical gallery has three branches in the form of an inverted Y. These galleries are mostly in the inner bark but also slightly score the sapwood; twenty-five to fifty eggs are laid in each gallery. The larvae mine directly away from the main galleries, scoring the bark and leaving the mines behind them filled with frass and excrement. They pupate at the ends of these mines in a cell formed in the inner bark. There are from three to five generations a year, depending upon the locality and season, with considerable overlapping of the various generations. The winter generation almost invariably attacks standing trees, possibly to avoid excess moisture in down logs. The other generations may all be in felled material or the tops of trees attacked by *Dendroctonus*.

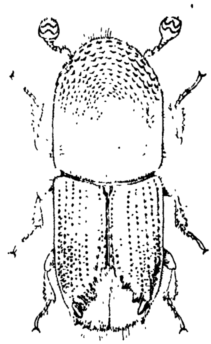

FIG. 34. The California five-spined engraver, *Ips confusus* (Lec.). × 8.

The Arizona five-spined engraver, *I. lecontei* Sw., is a western form related to *I. confusus*. It attacks *Pinus ponderosa* and probably other pines in Arizona. It often breeds up to great numbers in road slash, etc., and then attacks and kills second-growth ponderosa pine but cannot maintain its numbers in them.

The Vancouver five-spined engraver, *I. vancouveri* Sw., is also allied to *I. confusus* but is slightly larger, being 5.5 mm. in length. It attacks *Pinus monticola, P. lambertiana, P. contorta, P. balfouriana,* and *Picea sitchensis* in the mountains of California and north to the coast region of British Columbia.

The cloudcroft five-spined engraver, *I. cloudcrofti* Sw., is a smaller and more slender species 3.2 mm. in length which is related to *I. confusus* and is found in the high mountains of New Mexico, probably attacking the pines.

FIG. 35.- Top killing of ponderosa pine by the California five-spined engraver, *Ips confusus* (Lec.). These beetles frequently kill only the upper crown of the tree. The lower part may survive unless attacked by *Dendroctonus* beetles. (The red foliage shows as white in the photograph). (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Photo by Salman.*)

The large western pine engraver, *I. emarginatus* (Lec.), is a primary tree-killing species, quite capable of killing trees on its own account, but is more frequently associated with the mountain pine beetle in its attack upon ponderosa pine, lodgepole pine, and sugar pine and with the Jeffrey pine beetles when attacking Jeffrey

pine. The adults are the largest of our western species of *Ips* and are from 6 to 7 mm. in length, with three prominent spines and a fourth nearly obsolete spine on each side of the elytral declivity. Their work is characterized by the long, straight, nearly parallel galleries, 2 to 4 ft. in length, which run up and down the tree and connect at different points. Records from northern California indicate that this species has two generations a

FIG. 36. Work of the large western pine engraver, *Ips emarginatus* (Lec.), in inner bark of ponderosa pine. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Photo by Keen.*)

year, one that develops during the summer and another that carries the beetles through the winter. During the summer it requires 70 days for the beetles to attack a tree, raise a brood, and emerge as new adults. In the southern part of its range there are probably a number of summer generations with considerable overlapping of broods. It is found throughout the ponderosa-pine belt of California, Oregon, Washington, Idaho, and southern British Columbia.

I. knausi Sw. replaces *emarginatus* in the southern Rocky Mountains and is found throughout the ponderosa-pine belt of Arizona, New Mexico, and Colorado, where, besides ponderosa, it attacks lodgepole pine.

The smaller western pine engraver, *I. latidens* (Lec.), from 2.7 to 3.5 mm. in length, is one of the smallest of the engraver beetles found in the western states. It has three pairs of teeth on the margin of the nearly perpendicular elytral declivity, of which the third is the longest and most prominent. It confines its attack for the most part to dead or dying limbs of pine, seldom causing any primary injury, but occasionally it has demonstrated its ability to kill trees, particularly those weakened by mistletoe or drought. The typical work consists of a central nuptial chamber with from two to five short, slightly curved, radiating galleries and larval mines issuing singly from each egg niche. It attacks *Pinus ponderosa*, *P. lambertiana*, *P. jeffreyi*, *P. contorta*, *P. sabiniana*, and *P. monticola* through the pine belt of California, Oregon, Washington, and western British Columbia.

FIG. 37.—Work of *Ips latidens* (Lec.), in inner bark of Monterey pine. (*Photo by L. Davis.*)

I. guildi Bl. is a closely related Rocky Mountain form which attacks lodgepole pine in Colorado, Utah, Idaho, and Montana and probably other pines in that region.

I. longidens Sw. is an eastern species closely related to *latidens* (Lec.). It is found from Nova Scotia to New York State attacking white pine.

The California pine engraver, *I. plastographus* (Lec.), in the adult stage is a reddish-brown to black, cylindrical engraver beetle, from 4.3 to 5 mm. in length, with four pairs of spines on the posterior margin of the wing covers. The work is similar to that of *I. confusus*, the typical form having three egg galleries from 5 to 15 in. in length issuing from each entrance chamber. This species prefers to attack the trunks and branches of felled Monterey, Bishop, and lodgepole pine but at times also attacks weakened or dying standing trees. It is not often primary in its attacks but usually assists the Monterey pine engraver and the red turpentine beetle in killing living trees or trees injured by fire or other causes. It requires from six to eight weeks during the summer for broods to develop from eggs to new adults, emerge, and attack other trees. There may be from three to five

summer generations and one winter generation, depending upon the locality and the season. The winter is usually passed in the stage of

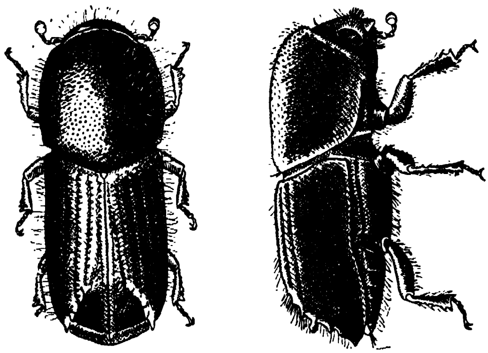

FIG. 38.—The California pine engraver, *Ips plastographus* (Lec.). Male, left, female, right. × 5. (*Trimble*.)

young adults under the bark of trees killed the preceding fall. It is found through the range of its host trees in the coastal region of middle California and in the Sierras.

FIG. 39.—Work of the California pine engraver, *Ips plastographus* (Lec.), in inner bark of Monterey pine.

I. integer (Eich.) is a slightly larger, doubtfully distinct species, from 4.5 to 6 mm. in length, which attacks ponderosa pine, western white pine, and lodgepole pine from British Columbia south to Cali-

fornia and Arizona and east through the Rocky Mountain region.

I. perturbatus (Eich.), from 4 to 5.5 mm. long, is an important secondary enemy of white spruce in northern Canada and Alaska and may at times become primary in its attacks.

I. avulsus (Eich.) breeds in the small branches of recently felled pines and is a secondary enemy of dying pines in the southeastern states from Mississippi and Florida north to Pennsylvania. From

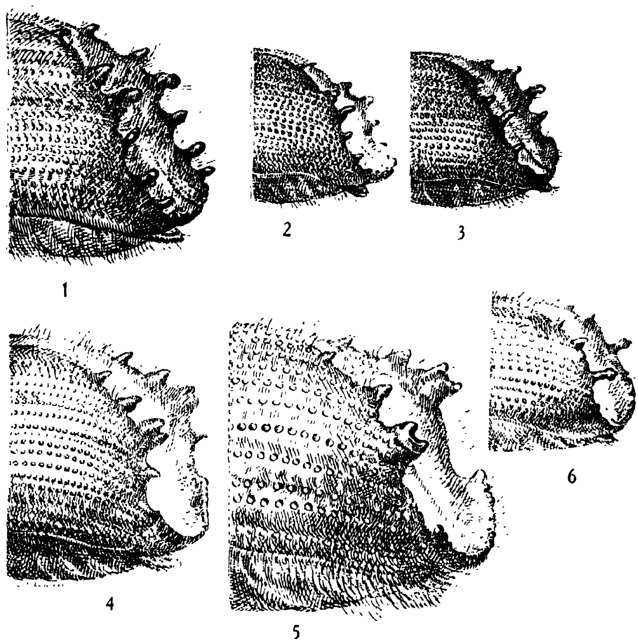

Fig. 40.—Posterior declivities of six species of *Ips* showing number and arrangement of spines. 1, *Ips ponderosae* Sw.; 2, *I. leconti* Sw.; 3, *I. plastographus* (Lec.); 4, *I. knausi* Sw.; 5, *I. emarginatus* (Lec.); 6, *I. radiatae* (Hopk.). × 13. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Edmonston.*)

two to five long and tortuous longitudinal egg galleries to each nuptial chamber are constructed in the inner bark, slightly scoring the sapwood.

The eastern pine engraver, *I. pini* (Say), 3.5 to 4.2 mm. long with four pairs of teeth on the margin of each elytral declivity, is the common species found in pines and spruce in the eastern United States and Canada. The egg galleries usually number from three to six to each nuptial chamber and are constructed in the inner bark, deeply scoring the sapwood. Eggs are placed singly in the niches, and the larvae feed out for a short distance in the inner bark, finally forming an enlarged pupal cell which scores the wood. After the new adults have

formed they remain under the bark for some time, cutting irregular meandering food tunnels which deeply engrave the sapwood. It is everywhere abundant in slashings and at times very injurious to living trees.

The Oregon pine engraver, *I. oregoni* (Eich.), while usually breeding in slash and felled trees, is at times an important primary enemy of

Fig. 41.—Work of the Oregon pine engraver, *Ips oregoni* (Eich.), in the sapwood of lodgepole pine. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Photo by Keen.*)

young pines and the tops of older trees. The adult beetles are about 4.5 mm. in length, with four pairs of spines on the posterior margin of the wing covers. The species is very closely related to *I. pini* (Say). The type of gallery, number of generations, and habits are all very similar to those of *I. confusus*, with which it is frequently associated in its attack upon ponderosa-pine slash. It is very common and widely

distributed through the pine belts of the Western states and Canada, where it attacks ponderosa pine, lodgepole pine, sugar pine, and digger pine. *I. perroti* Sw. is a rare species which infests red pine in Quebec. *I. borealis* Sw., 3.25 to 4 mm., is a secondary enemy of various spruces in Canada and has been reported by Hopping as breeding in *Abies lasiocarpa* in British Columbia. *I. interpunctus* (Eich.), closely related to *I. oregoni* (Eich.) is a more northern form which attacks Engelmann spruce and white spruce in Alaska, Yukon, and British Columbia. *I. interruptus* (Mann.), 4 to 5 mm. long, commonly attacks Sitka and white spruce in the Pacific Coast region from Oregon to Alaska. It is also reported from western white pine. *I. dubius* Sw. breeds in Engelmann spruce in British Columbia and the Canadian Rockies. *I. pilifrons* Sw., described from Colorado, has been found by Rust attacking Engelmann spruce in Idaho. *I. tridens* (Mann.), 3.8 to 4.8 mm., attacks Engelmann, Sitka, and probably white spruce in the Canadian Rockies and British Columbia. *I. engelmanni* Sw. is found in Engelmann and white spruce in the same region. *I. yohoensis* Sw. attacks *Picea engelmanni* and probably *P. glauca* in the Yoho Valley of British Columbia.

The Cypress Bark Beetles.—The members of the genus *Phloeosinus* Chap. are small stout bark beetles from 2 to 4 mm. in length, which are particularly destructive to various cypress and cedarlike trees belonging to the families Taxodiaceae and Cupressaceae. With the single exception of *P. pini* Sw., which attacks jack pine in Canada, all species in the genus confine their work to these two families of coniferous trees and are to be found working under the bark of trunk, tops, and limbs of healthy, weakened, dying, or felled trees.

Hopping's cedar twig beetle, *Phloeosinus hoppingi* Sw., is a very small (2 mm. in length) dull-brown to black species. It makes a short longitudinal transverse winding or branched egg tunnel from ½ to 1½ in. in length in the branches and twigs less than 1 in. in diameter of incense cedar and has also been recorded by Hopping as attacking *Juniperus scopulorum* limbs in British Columbia. It is distributed through the mountains of California, Oregon, and north to British Columbia.

P. antennatus Sw. is another similar species with antennae and caudal half of the elytra reddish brown. It also breeds in the limbs of incense cedar in the middle Sierras of California.

The minute cypress bark beetle, *P. swainei* Bruck, is another very small species which attacks the limbs of Sargent cypress in central California.

The western cedar bark beetle, *P. punctatus* Lec.—This is a small dark-red to black species 2.2 to 3 mm. in length, with very coarse

strial punctures and with the second interspace on the declivity narrower than the first or third, the latter heavily armed. It is a common and at times quite injurious bark beetle attacking western red cedar, incense cedar, Alaska cedar, and Port Orford cedar in the mountains of the Pacific Coast states from British Columbia south to central California. Felled or weakened trees are the preferred hosts, but at times the beetles appear to kill trees showing no particular injury or weakness. The trunk and larger limbs are selected for attack. The beetles bore beneath the bark in pairs and construct a small nuptial chamber from which one or two short galleries are extended. These may be simple and longitudinal, transverse oblique, or divergent at nearly right angles with one branch shorter than the other. Eggs are deposited in niches along the sides of the galleries, and the grubs upon hatching work out from the egg gallery and diverge so as not to cross one another's channels. Trees are attacked in April, May, and June.

Van Dyke's cedar twig beetle, *P. vandykei* Sw., is a brightly polished very small (2 mm.) reddish-brown species which is found attacking the twigs of incense cedar in the Sierras of California. It makes a short longitudinal egg tunnel from ½ to 1½ in. in length with from five to twenty-four diverging larval mines. These start transversely but turn parallel to the egg tunnel before pupation, which occurs under the bark parallel to the egg tunnel. It attacks limbs from 1 to 3 in. in diameter and, according to Hopping (1922), is capable of killing trees.

P. canadensis Sw. breeds in *Thuja occidentalis* in eastern Canada.

P. scopulorum Sw. is a small black species 2.8 mm. long, which infests the trunks of felled or weakened *Juniperus scopulorum* in British Columbia.

P. dentatus (Say) is the most common species found from Texas to Massachusetts attacking the red cedar, *Juniperus virginiana*, and white cedar, *Thuja occidentalis*.

In Mississippi *P. enixus* Bl. attacks red cedar, *J. virginiana*.

P. utahensis Sw. is about 3.5 mm. in length and attacks *J. monosperma* in Colorado and Utah.

The cypress bark beetle, *P. cupressi* Hopk.—This small bark beetle, together with its near relative *P. cristatus*, is very destructive to various species of cypress in California. Besides killing many trees outright, they have the habit of mining the twigs of ornamentals, causing the death of many twigs and rendering the tree very unsightly.

The adult is a small, cylindrical, stout, dark-brown beetle about 3 mm. in length. The eggs are whitish opaque, nearly transparent, very thin-skinned and delicate, oblong oval with no sculpturing, and

measure 0.775 by 0.6 mm. The larvae are cylindrical, curved, wrinkled, and white. The pupae are similar to other scolytid pupae.

Trees are attacked by numbers of these beetles, which bore through the bark and excavate longitudinal galleries (with the grain) between bark and wood, engraving both. Eggs are placed in niches along the sides of the gallery and are packed in with pitchy frass. The larvae upon hatching work out and away from the egg gallery so as to girdle the trunk and kill the tree. At the end of the larval mine an enlarged chamber is formed in the bark, where the larva pupates and changes

FIG. 42.—Work of the cypress bark beetle, *Phloeosinus cupressi* Hopk., in sapwood (left) and inner bark (right) of Monterey cypress.

to the adult form. When fully formed, the adult eats its way directly through the bark, leaving a small circular hole as evidence of its former presence. A certain proportion of the emerging brood dig food galleries in the small twigs. They enter the twig and hollow it out, leaving only a thin shell for support. Many of the twigs break of their own weight, and others fall with the first wind. Most of the twig mining is done in the spring and fall, although some work is apt to be found throughout the year.

The beetles overwinter in all stages except pupae in trees attacked the previous fall. In the spring some of the overwintered adults emerge and attack other trees, while others attack and mine the twigs. Eggs laid any time from Mar. 1 to Aug. 1 will develop to

the adult form before winter, and many of the earlier adults will emerge and attack other trees. Eggs laid in the fall will carry over the winter in the larval stage and emerge the following spring. Thus there is considerable overlapping of brood, but on the average 1½ generations will be completed during a year.

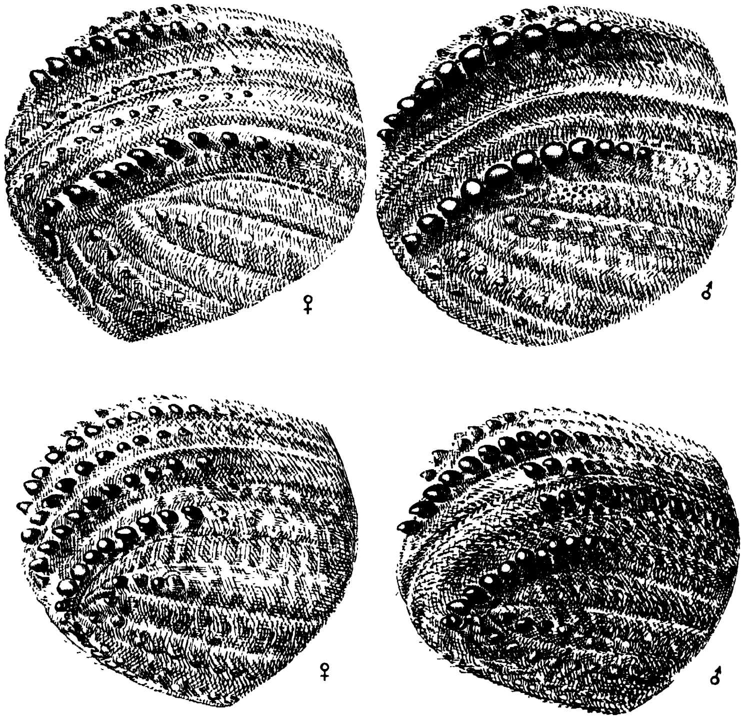

FIG. 43.—Posterior declivities of *Phloeosinus cristatus* (Lec.) (above) and *P. cupressi* Hopk. (below) showing the number and arrangements of the spines on the females (left) and the males (right). × 25. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Edmonston.*)

Practically all species of native and introduced cypress and related genera are subject to attack, including *Cupressus*, *Chamaecyparis*, *Cryptomeria*, *Thuja*, *Libocedrus*, and *Retinospora*.

The range of this species is more or less limited to central California. It is particularly destructive in the San Francisco Bay region.

The big-tree bark beetle, *P. rubicundulus* Sw., is 3 mm. in length with the elytra red-brown or shiny black. It is closely allied to *P. cupressi* and makes a short (2-in.) longitudinal egg tunnel in felled and dying big trees (*Sequoia gigantea*) in their native groves in the Sierras.

The Monterey cypress bark beetle, *P. cristatus* Lec., is a dark-brown to black species, 3 to 3.8 mm. in length, which is often associated with *P. cupressi* in its attack upon various cypress trees. Its habits and work are in most ways very similar to those of the former species. However, it usually forms its pupal cells slightly in the sapwood instead of in the bark, and its distribution covers a somewhat wider range, being found in Arizona and southern California as well as in the north-central region. It has been recorded from three species

FIG. 44. Work of the redwood bark beetle, *Phloeosinus sequoiae* Hopk. on inner bark of redwood.

of cypress, *C. macrocarpa*, *C. sargentii*, and *C. arizonica*. It is often destructive to planted cypress, particularly in Arizona.

The redwood bark beetle, *P. sequoiae* Hopk., 4 mm. in length, is the largest species in the genus. It makes a short, straight, longitudinal egg tunnel with diverging larval mines, similar to that of *P. cristatus*. It is not a particularly destructive species, since it confines its attacks to weakened, felled, or fire-scorched redwood and western red cedar. It is distributed from British Columbia south to central California.

The juniper bark beetle, *P. juniperi* Sw., is dark brown and from 3 to 3.8 mm. in length. It attacks the trunks of western juniper,

Juniperus occidentalis, in the Sierra region of California and north into Oregon, often killing the trees. The egg galleries are short, straight, and longitudinal, with diverging larval mines, making a very pleasing pattern.

P. rugosus Sw. is an allied species somewhat smaller (3 mm.) which is found breeding in the limbs of juniper in the same localities.

P. fulgens Sw. is 2.6 mm. long and breeds in the tops of small incense cedars on the west slope of the Sierras in California. Its egg galleries are from ½ to 1½ in. in length, straight and parallel to the grain. The larval mines are 1½ to 3 in. long and turn parallel to the grain ½ in. from the egg tunnel. The larvae enter the wood to pupate, and the pupal cells are parallel to the surface and grain of the wood.

In the Southeast, *P. taxodii* Bl. attacks southern cypress, *Taxodium distichum*.

The Fir Engraver Beetles.—The genus *Scolytus* Geoff. (*Eccoptogaster* Herbst) includes small, shiny, dark-brown or nearly black bark beetles which are easily recognized by the concave appearance of the posterior ventral surface of the abdomen. The adults attack in pairs and construct short, straight or forked tunnels from a central nuptial chamber, from which the larvae mine at right angles through the cambium and phloem, usually deeply scoring the sapwood and forming a very symmetrical pattern. Certain members of the genus are very destructive to various species of fir, while others attack other species of conifers as well as hardwood, fruit, and orchard trees. There are twenty-two species at present recognized in the United States.

The hickory bark beetle, *Scolytus quadrispinosus* Say.—This bark beetle is one of the most destructive enemies of hardwoods to be found in the United States. The loss to owners, manufacturers, and consumers of hardwood timber in the states of the Mississippi River Valley is estimated at about $15,000,000 per year. During recent years a large percentage of the hickory of these states has been killed. The adult beetles, 4 to 5 mm. in length, have the habit of feeding on the twigs and stems of leaves and buds during July and August, causing premature dying of some or all of the tree's foliage. They then gather on the trunk and larger limbs, bore through to the cambium, and start a gallery along which eggs are deposited. This main gallery runs up and down the stem and may be from 2 to 4 in. long. The larvae make side galleries and pupate in the outer portion of the inner bark. In the northern states, winter is passed as larvae in the bark of trees killed the preceding fall. The larvae complete their development during March and April, and the new adults emerge in May, thus completing one generation each year. In the South there is more

than one generation a year, and the larvae of the second generation hibernate. This species is widely distributed from Quebec to Georgia and west to Indiana, Missouri, and Utah, attacking all species of hickory, *Hicoria*, including the pecan.

S. muticus Say, 2.5 to 4.7 mm. in length, works in a manner similar to the above, making a short longitudinal gallery under the bark of hackberry, *Celtis;* but since it prefers dead, dying, or felled trees or broken, dying, or dead branches on living trees, its work is of little importance. Pupation may occur an inch or more in the wood. It is generally distributed through the East and South and west to Kansas.

S. fagi Walsh, length usually over 5 mm., is a species very closely related to the hickory bark beetle and is reported as attacking hackberry and beech in Illinois and Texas.

The European elm bark beetle, *S. multistriatus* (Marsh), is another pest introduced from Europe into New England, where it is a serious enemy of weak and sickly elms. The egg galleries are longitudinal, and pupation occurs in the outer bark. There are two generations a year. This species has recently assumed added importance owing to the fact that it is one of the principal carriers of the Dutch elm disease. *S. sulcatus* Lec., a native species, may prove to be another factor in spreading this disease, as elm seems to be its favorite host.

S. piceae Sw. is found in dying and dead limbs of red and white spruce, balsam fir, and larch in the northeastern states, eastern Canada, and west to Alberta and Indiana. The tunnels are lengthwise with the grain and usually have two branches, one above and one below the central nuptial chamber.

The Douglas fir engraver, *S. unispinosus* Lec. (*S. californicus* Lec.), is commonly found attacking weakened Douglas fir on the Pacific Coast, in the Rocky Mountain states, and in southwestern Canada. Although it sometimes kills small living trees, it prefers to attack those that are injured, dying, or have been recently killed and on this account cannot be considered a serious pest.

The adults are small, black, cylindrical shining beetles from 2.3 to 2.7 mm. in length, the males of which have a long spine projecting from the middle of the nearly perpendicular face of the ventral concavity.

The egg galleries are of the forked type and are constructed longitudinally with the grain of the wood. Frequently only one fork is completed, and the other is represented by a short spur at about a 45-deg. angle and from 2 to 3 mm. in length. At the junction of this and the main gallery is a circular opening large enough for the beetles to turn around in.

From 40 to 100 eggs are deposited in niches in the sides of the main gallery from 0.5 to 1 mm. apart. The larvae upon hatching work out at more or less of a right angle along the central portion of the gallery, while near the ends they work up or down so that the mines will not cross one another. The average length of the larval mines is 1½ in., although occasionally a mine will reach a length of 3 in. They usually lie about two-thirds in the wood and one-third in the bark.

In western Oregon, eggs and young larvae are most commonly found in February and March, and emergence of this brood takes place in late April, May, June, and July. At 4,000 ft. elevation, eggs and larvae have been found in late August, a fact that would indicate that there were two generations.

S. tsugae (Sw.), 3.4 mm. in length, attacks mountain hemlock and Douglas fir from British Columbia and Alberta south to California.

S. monticolae (Sw.) is similar to the above, 2.8 mm. in length, and is recorded by Swaine as attacking white pine and Douglas fir in British Columbia. It is also found in the northwestern states where it attacks *Pseudotsuga taxifolia, Abies grandis,* and *Abies* sp.

S. praeceps Lec. is a small species, 2.5 to 3 mm. in length, which makes two straight to slightly curved, transverse egg galleries from a central nuptial chamber in the branches and small tops of white and other firs in California, Oregon, Utah, Idaho, Texas, and New Mexico.

The white fir engraver, *S. ventralis* Lec., is at times exceedingly destructive to the white-fir forests of California and Oregon and is also found in other species of fir (*Abies*) through this region and north into Washington, Idaho, and British Columbia and south into Utah, Arizona, and New Mexico. Other recorded hosts are *Pseudotsuga taxifolia, Picea engelmanni,* and *Tsuga mertensiana.* The adults are slightly larger than *S. unispinosus,* from 3 to 4 mm. in length, and lack the prominent spine on the ventral concavity. The egg galleries are of the forked type but instead of being longitudinal are produced transversely from a small nuptial chamber for 2 or 3 in. in opposite directions. Eggs are placed singly in niches along the galleries, and the larvae, upon hatching, bore parallel channels longitudinally up and down the trunk at right angles to the primary egg tunnels. These galleries deeply score the sapwood, and the pattern thus impressed on the bark and sapwood is almost conclusive evidence of this species' presence. Pupation occurs in the inner bark at the end of the larval mine. Trees are attacked during July, August, and September, and the eggs hatch and larvae develop before winter. The winter is passed in the larval stage, and the new broods emerge the next year during the summer months. Thus there is only one annual generation.

S. subscaber Lec. was confused with *S. ventralis* until recently a species was found in California and Oregon which proved to be *subscaber* previously known only through the type. This recently rediscovered species is somewhat larger than *S. ventralis* and is from 3 to 5 mm. in length. It attacks and kills limbs and occasionally small dwarfed trees of *Abies magnifica* and *A. concolor*. It constructs an egg gallery resembling a capital E about ½ in. in width, marked

FIG. 45.—Work of the white fir engraver beetle, *Scolytus ventralis* Lec., on a section of white fir trunk. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Photo by Keen.*)

FIG. 46.—Egg gallery, larval mines and exit hole of *Scolytus subscaber* Lec. in *Abies magnifica*. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Photo by Miller.*)

deep in the sapwood. From twelve to thirty eggs are deposited in the cambium, and the larvae upon hatching work into the bark and do not score the sapwood until they are nearly full-grown. After pupation each new adult leaves the bark by a separate exit hole. There is one generation a year.

S. rugulosus Ratz. is the common shot-hole borer or fruit-tree bark beetle occurring in fruit trees and other deciduous trees from coast to coast.

The following species occurring on conifers have recently been described by Blackman (1934):

On *Pseudotsuga taxifolia: S. reflexus* Bl., in Arizona; *S. wickhami* Bl., in Colorado; *S. sobrinus* Bl., in Washington, Oregon, Wyoming; *S. fiskei* Bl., in New Mexico, Colorado; on *P. taxifolia* and *Abies concolor: S. oregoni* Bl., in Oregon; on *P. taxifolia, A. concolor,* and *A. lasiocarpa, S. robustus* Bl., in Colorado, New Mexico, Arizona; on *A. lasiocarpa: S. opacus* Bl., in Colorado and Utah; on *A. grandis: S. abietis* Bl., in Idaho; on *Larix occidentalis: S. laricis* Bl., in Montana and Idaho.

The genus *Pseudohylesinus* Sw. includes eight species of small suboval bark beetles with densely scaly elytra, which bore under the bark of various firs, spruces, and pines in the western United States and Canada.

The Douglas fir hylesinus, *Pseudohylesinus nebulosus* (Lec.), is a small, grayish to yellowish-brown variegated species about 3 mm. in length, which attacks recently felled or injured Douglas fir. It seems to prefer trees in the sapling or pole stage or limbs of larger trees, thus showing a distaste for thick bark, and frequently kills trees of small diameter. A short, longitudinal egg gallery is constructed in the cambium layer, often with two branches, one up and one down the trunk parallel with the grain of the wood and originating from a central entrance hole. In this respect it differs from all other species of the genus, which construct transverse egg galleries. The larval mines diverge from the egg gallery and end in pupal cells in the inner bark. At Ashland, Ore., at an elevation of 4,500 ft., there is one complete generation during the summer. Trees attacked early in May developed broods which emerged during September and October. A second generation passes the winter within the host trees. The species apparently restricts its attack to Douglas fir and is found through the range of this tree from British Columbia south to central California.

The grand fir bark beetle, *P. grandis* Sw.—Since this species prefers to attack weakened or dying trees of various ages and the limbs of old trees, the damage done by it is not particularly serious. The adult beetles are rather stout, elongate oval, densely clothed with brown and gray scales which sometimes form V-shaped markings on the elytra, and are from 2.8 to 3.8 mm. in length. They work in pairs and bore beneath the bark of trunk or limbs to construct their egg gallery. On reaching the cambium the parent adults construct a short transverse egg gallery for two or three inches, sometimes on only one side but more frequently on both sides of the entrance chamber. Eggs are placed in niches very close together, and the larvae on hatching burrow longitudinally above and below the egg gallery. The work is similar to that of *Scolytus ventralis* except that the egg gallery is narrower and not so uniformly straight. The

larval mines are for the most part in the inner bark and but slightly score the sapwood. Upon reaching full growth the larva constructs a pupal cell at the end of its mine which is wholly within the bark, and here the transformation from larva to pupa and from pupa to adult takes place. At the lower elevations and during the summer a brood can complete its development from eggs to adult in about six weeks. The beetles can thus complete one generation during the summer, while the second generation will overwinter in the adult stage. At the higher altitudes probably only one complete generation develops during a year. This species attacks Douglas fir, *Pseudotsuga taxifolia;* grand fir, *Abies grandis;* and white fir, *Abies concolor,* in the mountains of California, Oregon, Washington, and British Columbia and possibly extends east to Idaho and Colorado.

The larger fir bark beetle, *P. granulatus* (Lec.) is a large, very dark reddish to black species, measuring from 5 to 6.5 mm. in length, with very rough elytra and prominent striae. It is not uncommonly found in the mountains of British Columbia, Washington, Oregon, and California breeding in the roots of grand fir, white fir, and silver fir and is also reported from Douglas fir.

The hemlock bark beetle, *P. tsugae* Sw., is another stout species of moderate size and reddish-brown color, sparsely clothed with short, stout hairs and about 4.5 mm. in length. It breeds abundantly in felled and dying western hemlock *Tsuga heterophylla,* and is also known to attack and kill healthy trees. It is found in British Columbia and western Washington and will probably be found throughout the range of the host tree.

The Sitka spruce bark beetle, *P. sitchensis* Sw., is a species closely allied to *P. grandis* which is found attacking Sitka spruce in British Columbia, Washington, and Oregon.

The shore pine bark beetle, *P. sericeus* (Mann.), is a more slender species found under the dying bark of recently felled lodgepole pine, *Pinus contorta,* and possibly other conifers along the coast of Alaska and south to California.

The noble fir bark beetle, *P. nobilis* Sw., is a species closely allied to *P. grandis,* 3.9 mm. in length, which is found breeding in the noble fir, *Abies nobilis,* in Oregon and Washington.

The genus *Hylurgops* Lec. is closely related to *Hylastes* Er. but is distinguished by having the bases of the elytra usually rounded instead of nearly straight and the third tarsal segment much widened and bilobed. The habits are somewhat different, in that some species live in old, almost disintegrating logs and seem to be more social in habit, living in colonies. These may be hibernating. Others live under the bark at the base of the trunk of dying trees, the larvae

working very closely together in scarcely distinguishable mines. Since their work is confined to dead and dying trees they are of little or no economic importance.

The sour-sap bark beetle, *Hylurgops subcostulatus* Mann.—The adults are small, russet-brown, minutely scaly bark beetles from 3.4 to 4.5 mm. in length which attack the basal portion of the trunk of recently killed pines, especially those with wet, fermenting sap. The parent adults excavate a short, longitudinal, slightly irregular egg gallery in the inner bark, and the larvae upon hatching work out in all directions without making clearly differentiated mines. Pupation occurs in the inner bark. Trees are attacked in early spring and summer, and new broods emerge in the fall. A second generation then develops which passes the winter under the bark of newly infested trees as larvae and new adults, completing, as a rule, two generations a year. While very common in ponderosa pine it is also found in sugar pine, Jeffrey pine, western white pine, lodgepole pine, and probably other pines within its range, which extends from British Columbia south through the western United States into Arizona and New Mexico.

H. rugipennis (Mann.) is a more elongate reddish species from 4 to 5 mm. in length which is widely distributed from Alaska to California and is found breeding under the bark of injured, dying, and felled spruce, fir, Douglas fir, and pines. The adults excavate a short, curved, longitudinal and subtransverse gallery from the entrance hole under dying bark, and the larvae honeycomb the inner bark and cambium layers. Successive generations may breed in the same tree. Available records indicate two generations a year.

H. pinifex Fitch is similar to the above and works at the base of the trunk of pines, spruce, and eastern larch, often extending its tunnels below the surface of the ground. It is widely distributed in eastern Canada and eastern United States.

H. porosus (Lec.) is found in western white pine and other pines in most of the western states and British Columbia.

H. lecontei Sw. is found in ponderosa pine and probably also in in lodgepole pine from British Columbia south to Colorado, Nevada, and New Mexico.

The genus *Hylastes* Erich. (*Tomicus* Latr.).—The members of this genus are medium-sized dull-brown to black beetles with the third segment of the tarsi emarginate, not dilated; the tibiae with very large teeth; the beak short and stout but better developed than in other Scolytidae; the antennal funicle seven-segmented; the club oval, not compressed, and distinctly annulated; and with the bases of the elytra forming a straight line. They are for the most part typical root feeders, working under the bark of dying roots and in the basal

portion of the trunk of dying conifers, particularly the pines. They seem to prefer very moist bark, under which they construct a short, slightly curved or winding egg gallery. The larvae completely riddle the inner bark without making distinct mines. There are a large number of species, the biology of which is very little known. They are, however, purely of secondary importance.

The Douglas fir root bark beetle, *Hylastes nigrinus* (Mann.), is a slender black species, 4 to 5 mm. in length, the larvae of which excavate long winding mines in the bark of the roots of Douglas fir that is dying or has been recently killed. It is distributed from Alaska to California and is also reported from the Rocky Mountain region. In addition to Douglas fir it less commonly attacks western white pine, western hemlock, and probably other conifers. So far as is known, its attack is confined entirely to the roots and basal trunk of dying trees, so it is of little economic importance. The beetles commonly hibernate over winter in the moss on oak trees in the Willamette Valley of Oregon.

H. salebrosus Eich., a large, stout species more than 4 mm. in length, breeds in pines in the eastern and southern United States.

H. porculus Er., another large species, is found in the New England states south to Maryland and west to Michigan and in eastern Canada, breeding under the bark of pine roots.

H. macer Lec. is an elongate black species 5 to 6 mm. in length, which is reported from Engelmann spruce and recorded from British Columbia to California and Nevada and eastward through the Rocky Mountain region.

H. ruber Sw. is a rare red species 5 mm. in length which breeds in Douglas fir in southern British Columbia and south into Oregon.

H. tenuis Eich. is a smaller species reported from Florida to Virginia and west to Texas, breeding in pines.

The members of the genus *Dryocoetes* Eich. are medium-sized, stout, cylindrical bark beetles which attack various species of firs, spruces, pines, and a few broadleaf trees. Most of the species are secondary enemies, breeding under the bark of dying or dead trees or stumps. A few, however, are very destructive to healthy trees. They are mostly northern in their distribution.

D. pseudotsugae Sw., 4 to 4.8 mm. in length, reddish brown, constructs short and irregular galleries in the inner bark of windthrown and dying Douglas fir. The young adults gather in galleries in the outer or inner bark, not in the cambium, to pass the winter. Emergence occurs early in the spring. Trees attacked in the spring mature beetles by August. There is probably one and a partial second generation each year. The species can be considered as only a

secondary enemy of Douglas fir. It is very abundant through the range of its host tree in British Columbia, Washington, Oregon, and California. *D. americanus* Hopk. (*autographus* Ratz.) attacks the lower portion of the trunk of dead or dying trees or stumps of various spruces and some pines and larch throughout eastern North America and west to the Rocky Mountains. *D. septentrionis* (Mann.) attacks Engelmann, Sitka, and white spruce in Alaska, northern British Columbia, and eastward across Canada. *D. betulae* Hopk. attacks birch, beech, and wild cherry throughout the northern United States and Canada. The burrows are of the irregular radiate type with a variable number of egg galleries. It breeds in weakened and dying trees and in the stumps of recently felled trees and as a consequence is of little economic importance. *D. liquidambaris* Hopk. is, according to Blackman, a synonym of *D. betulae* Hopk. It is found in red gum in the southern states. *D. confusus* Sw. (*abietis* Hopk.), 3.4 to 4.2 mm. long, reddish brown, is at times a destructive species capable of attacking and killing healthy balsam firs. It constructs a central nuptial chamber with radiating egg galleries beneath the bark of *Abies lasiocarpa, Picea engelmanni,* and probably other spruces, firs, and pines in the Rocky Mountain region of Colorado, north into Canada, and west to British Columbia and south to Oregon. *D. affaber* (Mann.), less than 3.2 mm. in length, attacks Sitka and Engelmann spruce from Alaska southward through British Columbia to Washington.

D. piceae Hopk. is very closely allied to the above and is found breeding in spruce from North Carolina to Canada and westward to Michigan. *D. caryi* Hopk. was described from spruce in Maine.

The Wood Engravers.—The genus *Pityogenes* Bedel includes cylindrical beetles from 2 to 3.5 mm. in length which resemble *Pityophthorus* except that the teeth of the elytral declivity are usually much larger, at least in the males. They are polygamous in habit and excavate many galleries radiating from a central nuptial chamber between the bark and wood of small limbs and twigs of seedlings, young trees, and in the tops of old trees where the bark is thin.

The ponderosa pine wood engraver, *P. carinulatus* (Lec.), reddish brown, 3 mm. in length, usually attacks the trunks, limbs, and twigs of injured, dying, or recently felled ponderosa pine, whitebark pine, Jeffrey pine, and lodgepole pine. It cannot be considered as a primary enemy. It is found from Alaska southward into California and Arizona and eastward to Colorado and South Dakota.

The lodgepole pine wood engraver, *P. knechteli* Sw., is a stout species 2.8 mm. in length, commonly found under the thin bark of lodgepole pine associated with *Ips* in the western states and British Columbia.

P. fossifrons (Lec.) is found in *Pinus monticola* from British Columbia to California.

In the East *Pityogenes hopkinsi* Sw. is the most abundant bark beetle in the limbs of various eastern pines. It also occurs in white spruce and is found throughout eastern Canada and the United States. *P. plagiatus* (Lec.) occurs from Ontario to Virginia in southern yellow pine, red pine, and jack pine.

P. meridianus Bl. breeds in the dead and dying lower branches of loblolly and shortleaf pine which have been weakened by shading or ground fires in Mississippi.

The genus *Carphoborus* Eich. includes twelve species of small secondary bark beetles found occasionally breeding in the dying bark of coniferous trees. They usually work in or at the base of branches, on trees killed from other causes. The egg galleries are usually of the radiate type with from three to eight branches to each nuptial chamber, indicating that the species are decidedly polygamous. They are of little economic importance.

Species so far described include:

C. simplex Lec., 2.2 mm. long, found in California and Oregon breeding in the dying bark of branches and small tops ot ponderosa pine and sugar pine.

C. vandykei Bruck, a closely related species which breeds in Douglas fir in California and Oregon.

C. radiatae Sw., black with dark-reddish elytra. It is found in California breeding in the branches of Monterey pine, ponderosa, and lodgepole pine.

C. carri Sw., breeding in white spruce from the eastern slopes of the Rockies straight across northern Alberta and Saskatchewan into Manitoba.

C. blaisdelli Sw., breeding in pines in California.

C. swainei Bruck, breeding under the bark of small dead branches of digger pine and Jeffrey pine in California.

C. sansoni Sw., found attacking white spruce in Alberta.

C. andersoni Sw., breeding in *Picea canadensis* in the Northwest Territories.

C. dunni Sw., recorded from red spruce in the province of New Brunswick.

C. ponderosae Sw., breeding in ponderosa pine in British Columbia and Utah.

C. bicristatus Chap., breeding in weakened, dying, or cut branches of pine in the Southeastern states.

C. bifurcus Eich., closely related to *bicristatus*. It occurs under the bark of branches of various pines in the Gulf and Atlantic states.

The genus *Cryphalus* Erich. is represented in the United States by eleven species of very small, stout bark beetles. The egg galleries usually consist of an enlarged chamber beneath the bark of the base of twigs, in which the eggs are loosely deposited and covered with frass. The larvae work out for a short distance in all directions, finally pupating in the inner bark. The genus is more northern in its distribution, and the various species confine their attacks to firs, spruces, and related trees. Since dying, weakened, or dead trees are usually selected for attack, these beetles rarely do much damage and hence are of little economic importance. *C. pubescens* Hopk., 1.0 mm. long, brown with darker pronotum and head, breeds in *Abies grandis* in Washington. *C. subconcentralis* Hopk., 1.85 mm. long, reddish brown, is found in Douglas fir and grand fir in British Columbia and south to Oregon. *C. rubentis* Hopk. breeds in *Picea rubens* in West Virginia. *C. fraseri* Hopk. breeds in *A. fraseri* in North Carolina. *C. canadensis* Chamb., 1.8 mm., brownish black with reddish pronotum, attacks *A. lasiocarpa* in British Columbia. *C. grandis* Chamb., a small black species 1.8 mm. long, attacks *A. grandis* in Oregon. *C. amabilis* Chamb., 1.2 to 1.6 mm. long, dark brown to black, attacks seedlings and small saplings of silver fir, *A. amabilis*, and Douglas fir, *Pseudotsuga taxifolia*, in Oregon.

C. approximatus Hopk., 1.73 mm., dark brown with lighter pronotum, attacks *A. grandis* in Idaho.

C. balsameus Hopk., 1.9 mm. long, reddish brown to black, attacks *A. balsamea* in Maine.

C. mainensis Bl., 1.63 mm. long, attacks red and white spruce in Maine and New York.

The species of the genus *Crypturgus* Erich. are among the smallest of the Scolytidae, from 1 to 1.5 mm. in length. They confine their work almost entirely to the inner bark of coniferous trees, making short, winding mines which start from the tunnels of other bark beetles, such as *Dendroctonus*, *Ips*, *Polygraphus*, and *Dryocoetes*. They are often found in great numbers but are of little or no economic importance.

Crypturgus atomus Lec., 1 mm. in length, slender, dark brown to black, is a very widely distributed species found in Europe, Asia, Japan, and northeastern North America as far south as West Virginia and west to Ohio. Packard records it as in white pine, in balsam fir, and in hemlock; while Hopkins adds other species of pines, black spruce, and Norway spruce. It prefers to attack moist, dead bark of trees killed by other scolytids, where it makes relatively short (from $\frac{1}{2}$ to $2\frac{3}{4}$ in.), sinuous egg galleries, often radiating from the nuptial chamber of other scolytids. The larval mines are entirely

within the inner bark. There appears to be only one annual generation, with the winter passed in the adult stage. It is decidedly of secondary importance.

C. alutaceus Sz. is found from New Jersey to Florida in the dead bark of black and Norway spruce.

C. borealis Sw. is 1.2 mm. in length and is found breeding in larch, white and Sitka spruce, and alpine firs through Manitoba, Alberta, and south through the Rocky Mountains and in the Pacific Coast states.

The genus *Dolurgus* Eich. is represented in the United States by one species, *Dolurgus pumilus* (Mann.), from 1.6 to 2 mm in length, commonly found constructing galleries which start from those of species of *Ips* and *Dendroctonus* in the bark of pines and spruces. It is distributed through the Pacific Coast region from British Columbia south to central California and has been found in the dying bark of Sitka spruce, Engelmann spruce, Douglas fir, western white pine, and Bishop pine. There appears to be only one generation a year. Because of its habits it is of decidedly secondary importance.

Members of the genus *Orthotomicus* Ferr. are small bark beetles from 2 to 3.4 mm. in length which work under the thick bark of the trunk of coniferous trees, sometimes intermingling their mines with those of *Dendroctonus* beetles. They form a central nuptial chamber with short radiating egg galleries, similar in appearance to those of *Pityogenes*. From one to six eggs are laid in large niches or pockets along the galleries. So far as is known they are usually secondary enemies.

Orthotomicus caelatus (Eich.) (*Tomicus*) in the adult stage are reddish-brown to black bark beetles 2.3 to 3.3 mm. in length. They breed under the thick bark of pines, spruces, and larch, often completing the destruction of weakened trees, and in company with other bark beetles assist in killing apparently healthy trees. They are usually not considered an important enemy. The egg galleries are of the radiate type, similar to those of *Ips*, since the species is polygamous, except that the galleries are shorter and from two to six eggs are laid in each egg pocket. *O. vicinus* (Lec.) is the western representative of the above and doubtfully distinct. It infests the bark of lodgepole pine, Engelmann spruce, and western larch in western Canada, northwestern United States, and south to Colorado. *O. punctipennis* (Lec.) is a similar though rare eastern form. *O. ornatus* Sw. is a small species 2.3 mm. in length which infests the thick bark at the base of *Pinus ponderosa*, *P. jeffreyi*, and *P. contorta* and is distributed from Arizona north through California and Oregon to

British Columbia. *O. lasiocarpi* Sw., 2 mm. in length, infests the thick bark of dying *Abies lasiocarpa* in British Columbia.

Genus *Pityokteines* Fuchs. These are small bark beetles from 1.7 to 2.5 mm. in length which work beneath the bark of the trunk and branches of various balsam firs and spruces. They are usually secondary enemies, attacking dying or felled trees, but occasionally have been noted attacking standing small trees in crowded stands. They make a central nuptial chamber with from five to eight radiating egg galleries.

Pityokteines sparsus (Lec.) (*balsameus* Lec.) (*Tomicus*), 2 to 3 mm. long, is frequently a destructive enemy of eastern balsam, killing large groups of trees. The beetles also attack eastern pines, spruce, and larch. They may attack seemingly perfectly healthy trees but also work in weakened trees and in limbs and tops. They are polygamous in habit and construct a central nuptial chamber with several transverse branches. Eggs are placed in large niches, and the larvae make their tunnels longitudinally, following the grain. *P. elegans* Sw., 2.5 mm. in length, the female with long hairs on the front, is a common small secondary bark beetle attacking balsam firs, *Abies concolor* and *A. magnifica*, and is frequently found working with *Pseudohylesinus*. It is distributed through the high mountains of California and north into British Columbia. *P. minutus* (Sw.) is a widely distributed small and inconspicuous bark beetle attacking the dying bark of *Abies lasiocarpa* and *Pseudotsuga taxifolia* in California, Oregon, and Wyoming. *P. jasperi* Sw. is doubtfully distinct from the last and is found attacking the same host trees from Oregon northward to Canada and eastward to Alberta.

The genus *Polygraphus* Erich. is represented on this continent by one widely distributed species and another of more local distribution.

The four-eyed spruce bark beetle, *Polygraphus rufipennis* Kirby, is a stout, black, cylindrical bark beetle 2 to 3 mm. in length. It is found abundantly throughout the spruce forests of Alaska, Canada, and the northern United States, from the Pacific Coast to Newfoundland and south to Georgia and Louisiana. It is usually found breeding in the dead and dying bark of black and white spruce and of larch and in logs, stumps, tops, and dying branches. At the base of the entrance tunnel a central nuptial chamber is cut out, from which radiate three to five irregular short egg galleries, which engrave the bark without scoring the wood. Adults appear in the spring with the opening of balsam buds and are to be found flying and attacking spruce trees until late in October. There is only one annual generation.

P. hoppingi Sw. is a closely related species which breeds in *Picea engelmanni* in Arizona.

The genus *Scierus* Lec. is represented by two species of small, reddish-brown bark beetles which breed under the bark of dying spruce through the forests of the northern part of the continent and at the higher elevations.

Scierus annectens Lec., 3.6 mm. long, breeds under the bark of white spruce in Quebec and Engelmann spruce in British Columbia, Utah, Arizona, and California.

S. pubescens Sw., 4.3 mm. long, is found in spruce in Alberta.

The genus *Xylechinus* Chap. is represented in the United States by the single species *X. americanus* Bl., described from Maine. The adults are dark-brown bark beetles 2.2 mm. in length, which breed in suppressed trees of white and red spruce and white pine. The egg galleries found under the bark usually consist of two or more tunnels branching transversely from a central entrance chamber. It is of little or no economic importance.

THE CONIFEROUS TWIG AND CONE BEETLES

A large group of very small cylindrical scolytid beetles have acquired the habit of working under the bark of the smaller twigs and branches into the pith of twigs and into the cones. Such a large proportion of the species in the genera *Pityophthorus*, *Myeloborus*, *Pityoborus*, and *Pityophilus* have this habit that they have come to be called "twig beetles" even though some of the species may work under the bark of the trunk or larger limbs of mature trees.

The Coniferous Twig Beetles. The genus *Pityophthorus* Eich. includes a very large number of species of very small cylindrical bark beetles which for the most part breed in the twigs of coniferous trees. The majority of the species construct a central nuptial chamber between the bark and wood of pine twigs from which radiate several egg galleries, each occupied by a female beetle. The male occupies the central nuptial chamber and assists with the construction of the galleries, and the larvae upon hatching work through the cambium of the twig's bark and finally pupate at the ends of the larval mines. Upon changing to adults they eat their way directly to the surface and fly to attack other twigs. Others construct their egg galleries in the pith of twigs, and the larvae feed on the pith, wood, or bark and completely riddle the twigs. The number of generations varies with the different species and with different localities, but usually there are two or more generations each year. At present 108 species are described from North America, the majority feeding in the twigs of pines. They are frequently found in the twigs of trees attacked by different species of *Ips* and *Dentroc-*

tonus bark beetles, in which case their work is purely secondary. At times they are injurious to twigs of living trees and apparently contribute to their death. Sometimes they occur on medium to large branches and occasionally even on the trunks of large trees. For a discussion of the various species the reader is referred to a recent monograph by Blackman (1928), as only a few of the more common forms may be mentioned here.

Pityophthorus puberulus Lec., black in color, 1.4 to 1.6 mm. long, is a common species in balsam fir in the East and is often taken in eastern spruces, besides breeding in all species of pines within its range, which extends from eastern Canada south to North Carolina and west to Wisconsin and Kansas.

P. opaculus Lec., reddish brown in color, 1.34 to 1.65 mm. long, is distributed from Maine to West Virginia and west to South Dakota. Its favorite hosts are the various species of spruce, but it is also found attacking pines and balsam fir.

P. pulicarius (Zimm.), brown to black in color, 1.3 to 2 mm. long, attacks and kills either injured or normal green twigs and constructs its egg galleries in the pith or sapwood. It attacks all species of pines within its range, which extends from Florida to Maine and west to Wisconsin.

P. confinus Lec., dark reddish brown in color, 2.5 to 2.8 mm. long, commonly attacks and kills the leaf-bearing portion of injured or living twigs of ponderosa pine, the larvae feeding on the bark, sapwood, and pith. It also attacks Jeffrey and Coulter pine and is distributed from British Columbia south through California and east through Arizona, New Mexico, and Colorado.

P. cariniceps Lec., dark reddish in color, 2.3 to 2.5 mm. long, is very commonly found breeding in the twigs and small branches of white pine and Norway pine in the region from eastern Canada south to Pennsylvania and west to Wisconsin. It has also been taken from balsam fir.

P. tuberculatus Eich., reddish brown in color, 1.5 to 2.3 mm. long, is a very common species widely distributed throughout the Western states, where it breeds in the branches and twigs of most species of pines as well as white fir and Engelmann spruce.

P. carmeli Sw., black in color, 2.5 to 2.7 mm. long, is commonly found attacking the limbs and twigs of Monterey pine and Torrey pine in the coast region of central to southern California. Sometimes it becomes very abundant and destructive, killing weakened Monterey pine.

P. intextus Sw., reddish brown, 1 8 mm. long, is reported as abundant in spruce and larch in Alberta and British Columbia.

P. pseudotsugae Sw., dark reddish brown in color, 1.9 to 2.1 mm. long, is the species most frequently encountered in the limbs and tops of firs associated with the destructive work of the white fir engraver, *Scolytus ventralis* Lec. It is found distributed from British Columbia south through California and east to Montana and Colorado, attacking nearly all species of the true firs as well as Douglas fir.

P. nitidulus (Mann.), reddish-brown in color, 2.4 mm. long, is a very common coastal species of the Pacific slope. It is distributed from Alaska southward through California and is found attacking nearly all the spruces and pines within this range. It is a bark-infesting species, making the typical star-shaped or radiate egg galleries from a central nuptial chamber.

FIG. 47.—Work of *Pityophthorus pseudotsugae* Sw. on twig of Douglas fir.

P. pulchellus Eich., dark reddish brown to nearly black, 2 mm. long, is a common species of the eastern states, found attacking various pines as well as red spruce and balsam fir. It is distributed from Maine to North Carolina and west to Texas.

P. pullus (Zimm.) is reddish brown in color, 1.8 to 2.66 mm. long, is found throughout the Eastern states and west to Texas, breeding in various species of pine.

P. consimilis Lec. (*canadensis* Sw.), reddish-brown in color, 1.64 mm. long, is widely distributed over the eastern half of the continent, where it breeds in various species of pine and is also taken from spruce and balsam fir.

P. annectens Lec., dark reddish brown, 1.3 to 1.75 mm. long, breeds in various species of pines in the southern states.

P. solers Bl., dark reddish brown in color, 2.06 mm. long, is found in New Mexico and Arizona breeding in the true firs and Douglas fir.

The Pith Twig Beetles.—The adults of the genus *Myeloborus* Bl. bore directly into the pith of live, healthy lateral twigs, usually from the underside of the twig, near the base of the leaf-bearing portion, causing the formation of a small pitch tube. The egg gallery is constructed within the pith of the twig, and a few eggs are laid in small niches along it. The larvae eat through the pith and bore outward into the wood, extending the cavity of the egg gallery, without making definite tunnels, and finally so destroy the interior of the twig as to cause it to die. After changing to adults the beetles remain and feed within the twig for several weeks before emerging. While often injurious to small trees, at times they can be considered a

benefit to the forest by causing the death of lateral branches so that the lumber will be more free from knots. Eight species have been found attacking pines in various parts of the country. For a description of the species the reader is referred to a recent work by Blackman (1928). *M. amplus* Bl. attacks and kills ponderosa pine twigs in Arizona and New Mexico. *M. fivazi* Bl. is injurious to young trees of red pine in New York, often killing numerous twigs on the lower branches and decreasing the vitality of the trees. *M. boycei* Sw. in California and Oregon and *M. iniquus* Bl. in Wyoming and Colorado breed in twigs of lodgepole pine and ponderosa pine.

The genus *Pityoborus* Bl., includes two species of rare twig beetles related to the above. *P. comatus* (Zimm.), is found in the southern states, where it breeds in the shaded-out lower limbs of pine. The galleries are radiate and mostly transverse, while the larvae make very short alcoves which gradually widen and join those of their neighbors, the while feeding on both bark and sapwood. The species is of little or no economic importance.

The genus *Pityophilus* Bl. includes one rare species (*P. barbatus* Bl.) which is closely related to the last two genera and is found attacking piñon, Mexican white pine, and ponderosa pine in New Mexico and Arizona. It is of little importance.

The Cone Beetles, Genus *Conophthorus* Hopk.—The adults of this genus are small, stout, shiny, dark-brown to black beetles, from 1.25 to 4 mm. in length, which confine their work to small, immature pine cones and the supporting stem. The attack is made on the cone stalk and causes a pitch tube to form. The adult beetles bore a small tunnel to the center of the stem, then turn toward the cone and extend the gallery through its axis. In this tunnel the eggs are deposited singly in niches at intervals on each side and are then packed in with sawdust. The young larvae hatch into tiny white legless grubs, which feed upon the scales, seeds, and tissues of the withering cone, often honeycombing the interior. The destruction of the seed crop by these beetles often assumes serious proportions. Some fifteen species have been described in the United States, most of them named after the host tree whose cones they attack.

The piñon cone beetle, *C. edulis* Hopk., is a small, dark species with reddish elytra, 1.25 to 2.75 mm. in length, which is very destructive to the cones of *Pinus edulis* in Colorado, Arizona, and New Mexico. *C. taedae* Hopk. probably infests the cones of *P. taeda* in Virginia. *C. virginianae* Hopk. lives in the cones of *P. virginiana* in West Virginia. *C. resinosae* Hopk. attacks the cones and shoots of *P. resinosa* in the New England states, New York, and Canada.

The ponderosa pine-cone beetle, *C. ponderosae* Hopk., 3.50 to 3.85 mm. long, with dark-brown to black pronotum and reddish-brown elytra, attacks ponderosa pine cones in their second year of growth during May, when the cones are from 1 to 1½ in. long. In a few cases first-year cones are attacked, but in such cases eggs are not deposited, nor can the brood develop. The attack and development are somewhat earlier than in the case of the sugar pine-cone beetle, and ordinarily the attacked cones do not drop from the trees. In some years this species is responsible for the destruction of from 30 to 50 per cent of the ponderosa pine-cone crop. It is probably distributed throughout the range of its host tree (*Pinus ponderosa*) and has been recorded not only in Oregon and California but from Colorado and Arizona. Occasionally it attacks the cones of Jeffrey pine.

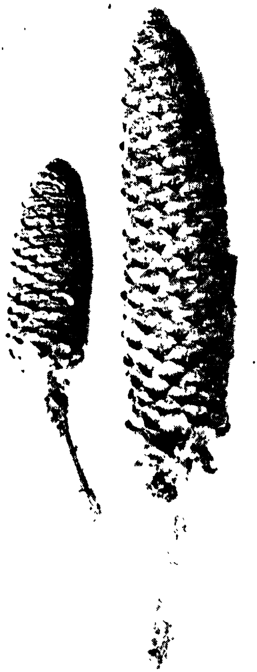

FIG. 48.—Blighted cones showing pitch tubes where the sugar pine-cone beetle, *Conophthorus lambertianae* Hopk. has attacked the stem of the cone. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Photo by Patterson.*)

C. scopulorum Hopk., which is doubtfully distinct, has been recorded from the Rocky Mountain form of *P. ponderosa* in Colorado and Arizona. *C. apachecae* Hopk., 3.5 to 3.9 mm., dark brown with dark-reddish elytra, probably attacks the Apache pine, *P. apacheca*, in Arizona. *C. coniperda* (Sz.) attacks the cones and twigs of *P. strobus* in Michigan, Virginia, and north into Canada. *C. radiatae* Hopk., 2.4 to 3.6 mm., black, shining, breeds in the cones of *P. radiata* in California. *C. contortae* Hopk., 3.1 mm., shining, blackish brown, attacks the cones of the beach form of lodgepole pine, *P. contorta*, in Oregon. *C. monticolae* Hopk., 2.95 to 3.45 mm., black to reddish brown, lives in the cones of *P. monticola* in Idaho and north into Canada.

The sugar pine-cone beetle, *C. lambertianae* Hopk., is responsible, on certain areas and in certain years, for the destruction of from 30 to 90 per cent of the seed crop of sugar pine. This loss may be considered as serious on areas where only a few seed trees have been left after cutting and where natural seeding is desired. The adults are black, shining beetles from 2.85 to 3.95 mm. in length. They pass

the winter in the cones killed the previous year and in May and June emerge and attack small cones from 2 to 3 in. in length which are beginning their second year of growth. Eggs are laid, and the larvae grow rapidly and pupate in four to six weeks. All attacked cones drop from the tree, and the brood finish their development in the fallen cones. The beetles are all mature by the beginning of August but do not leave the cones until the following May, spending about eight months in the cones as mature beetles. The species is found throughout the range of its host tree *P. lambertiana* in Oregon and California, attacking both sugar pine and western white pine cones.

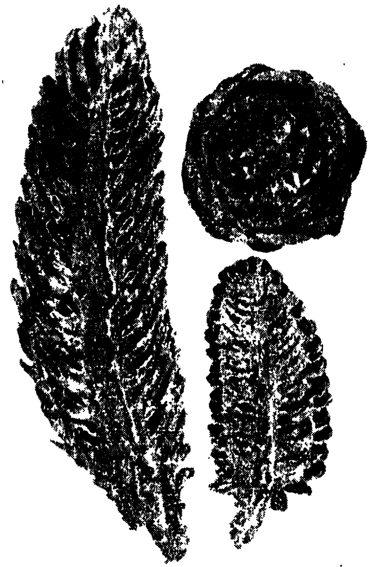

FIG. 49.—Work of the sugar pine-cone beetle, *Conophthorus lambertianae* Hopk., in sugar pine cones. Blighted cones opened to show egg galleries through the axis and the work of the larvae in the seeds. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Photo by Miller.*)

BARK BEETLES ATTACKING BROADLEAF TREES

Broadleaf trees are also subject to attack by a great variety of scolytid bark and twig beetles. Most of these are small beetles which work in the twigs and small branches, but a few attack the main trunk and larger limbs and at times may be responsible for the death of trees. They are largely distributed through the eastern and southern states where broadleaf trees are the most numerous. In the following discussion the genera are arranged in alphabetical order.

The genus *Alniphagus* Sw. is represented by one species. The alder bark beetle, *Alniphagus aspericollis* (Lec.) (*Hylesinus*), is a common and often quite destructive enemy of western alders. The beetles usually attack weakened, dying, or felled trees but at times kill both young and old ones. The adults are small, robust, cylindrical bark beetles 3.5 to 4 mm. long. They bore through the bark in pairs, usually at the base of branches, and construct an egg gallery from 2 to 5 in. long, running up or sometimes down the trunk parallel with the grain of the wood. An enlarged nuptial chamber is not formed. Egg niches are placed very closely together along the gallery, with as many as fifty eggs to an inch of gallery. The larval mines are perpendicular to

the egg gallery, and the pupal cells are usually a short distance out in the soft inner bark. Trees may be attacked throughout the growing season. From those attacked in spring and early summer, broods of new adults emerge before fall. Beetles attacking in late summer and fall overwinter in the larval and new adult or parent adult stages. There are apparently at least two generations a year. The species is distributed through the Pacific Coast region, from British Columbia southward through California, following the range of the host trees—red alder, *Alnus rubra*, white alder, *A. rhombifolia*, and Oregon alder, *A. oregona*.

The genus *Abrosiodmus* Hopk. contains three species of small bark beetles restricted to the Eastern states, which are rare and of little or no economic importance. *A. tachygraphus* (Zimm.) was reared from *Betula* sp. at Washington, D. C.

The genus *Chramesus* Lec. includes a few species of small "hump-backed" bark beetles, with large, oval, unsegmented antennal clubs. They attack the branches of various hardwood trees. The egg galleries are short, straight, and longitudinal, extending from an enlarged nuptial chamber and forming a very regular and pleasing pattern. They are not a particularly injurious group, since they confine their work for the most part to the smaller branches and twigs which have been injured and are dying. *Chramesus hicoriae* Lec., 1.5 to 1.8 mm. long, attacks the smaller branches and twigs of hickory throughout the range of these trees in the eastern and western states and in Canada. *C. chapuisi* Lec. is very similar to the above. It attacks hackberry (*Celtis* spp.) through the southern states and west to Kansas. Three species have been described by Schaeffer (1908) from Arizona, of which *C. dentatus* Schffr. is known to breed in oak twigs which have been girdled by *Oncideres quercus* Skin. Several undescribed species are very common in locust in Arizona.

The genus *Cryptocleptes* Bl. is represented in the East by *C. dislocatus* Bl., a common species breeding in limbs and twigs of hickory, pecan, and acacia in Mississippi, West Virginia, North Carolina, South Carolina, and Texas.

The genus *Dendrosinus* Chap. is represented in this country by one species, *D. bourreriae* Sz., found in the Florida Keys. It bores a small hole horizontally into the wood of the trunk of *Bourreria havanensis*, and the larvae work longitudinally, paralleling the grain of the wood. Outside its interest as a representative of this genus in our fauna, it is of no particular importance.

The genus *Erineophilus* Hopk. is represented by the single species *schwarzi* Hopk. Schwarz collected this species at Coconut Grove,

Fla., where he found it boring under and killing the branches of the banyan tree (*Ficus*).

The genus *Hylocurus* Eich. (*Micracis* Lec.) (*Micracisoides* Bl.) includes several species that bore in the sappy wood of limbs and trunks of various broadleaf trees. They are of polygamous habit, and after entering the sapwood the different females excavate branching egg galleries. The larvae feed in the wood, running their mines longitudinally. They may kill trees after working in the wood for several generations, but for the most part they attack sickly or weakened trees and cut branches. *Hylocurus rudis* Lec. works in the limbs of *Acer*, *Hicoria*, *Celtis*, and *Castanea* and is found in Mississippi, North Carolina, Maryland, Georgia, and Michigan. *H. biorbis* Bl. is found in hickory limbs in New York, Pennsylvania, Maryland, and North Carolina. *H. bicornus* Bl. and *H. harnedi* Bl. were described from Mississippi from specimens taken in dead hickory limbs. *H. spadix* Bl. also breeds in hickory limbs in North Carolina and Pennsylvania. *H. langstoni* Bl. breeds not only in the limbs but in the trunks of honey locust, hackberry, slippery elm, and mulberry in Texas, Mississippi, and Maryland and after several generations may kill standing trees. *H. parkinsoniae* Bl., dark reddish brown, 2.17 to 2.4 mm. long, is distributed through the desert region of southern California, through Arizona to Texas, and breeds in the dead wood of the horse bean, *Parkinsonia* spp.; palo verde, *Cercidium* spp.; and persimmon, *Diospyros virginiana*.

The genus *Hylurgopinus* Sw. (*Hylastes*) includes a single species in the United States. The dark elm bark beetle, *Hylurgopinus rufipes* Sw. (*Hylesinus opaculus* Lec.), from 3.25 to 3.75 mm. in length, mines under the green bark of sickly and dying elms and basswood in the eastern United States and Canada.

The genus *Hypothenemus* Westwood includes very minute bark beetles, reddish brown to black, seldom more than 1.25 mm. long, which work in the inner bark of dead limbs and twigs of a great variety of trees. Most of the species are found in the Southeastern states. They rarely if ever breed in anything except dead bark and hence are of no economic importance. Twenty-six or more species have been described from the United States, and the reader is referred to the works of Hopkins and Blackman for further information concerning them.

The genus *Leperisinus* Reitter are small bark beetles with scaly bodies and variegated markings. They are particularly destructive to the various species of ash, *Fraxinus*, and related trees and breed in both living and dying branches and tops. The egg galleries consist of two straight or slightly curved transverse branches from a central

nuptial chamber, while in the smaller branches the galleries obliquely encircle the limbs, and the larval mines proceed longitudinally up and down the stem. Seven species are found throughout the United States and Canada. The ash bark beetle, *Leperisinus aculeatus* (Say) is the most common representative of the genus. The adults are from 2.1 to 3 mm. in length, with three nearly transverse bands of cinereous scales on the elytra. It is distributed throughout the United States and Canada east of the Rocky Mountains, following the range of its host trees and white ash in the East, Oregon ash in Oregon and California, and ash in Arizona. Its work is confined for the most part to the branches of sickly or weakened trees and hence is not seriously harmful. In the Southern states there are from two to three generations a year. It is heavily parasitized by Hymenoptera and mites. *L. criddlei* Sw. is of smaller size than the above (2 to 2.6 mm.) and is found attacking green and white ash in Quebec and Manitoba. *L. cinereus* Sw. is a rare species which attacks ash in Quebec and Massachusetts. *L. imperialis* (Eich.) is a large species, 3 mm. or more in length, with markings like *aculeatus*, which is widely distributed throughout the United States but is not common. *L. fasciatus* (Lec.), 1.5 mm. in length, is a pretty little black species with whitish and yellow-brown markings. It is found in Pennsylvania and New York attacking ash. *L. californicus* Sw. is often destructive to ash in California.

FIG. 50. — Work of *Leperisinus californicus* Sw. on ash.

The genus *Loganius* Chap. is represented by the species *ficus* Sz., which attacks the golden fig, *Ficus aurea*, in southern Florida. Schwarz found it in crowded colonies under the bark, so that "nothing can be said of the nature of the galleries."

The genus *Lymantor* Loev. is represented in the United States by only one eastern species, *L. decipiens* Lec., which burrows entirely within the wood of dead dry limbs and sprouts of maple, hickory, and apple. The entrance burrow penetrates the wood, and then two or three egg galleries are extended in both directions longitudinally with the wood. Eggs are laid in niches, and the larvae burrow more or less transversely. The food of both larvae and adults appears to be a black fungus which stains the wood. They are of no economic importance.

Members of the genus *Micracis* Lec. have an acuminate sutural apex, the antennal scape flattened, and the foretibiae with the outer edge nearly straight. They are typically wood borers, driving their

egg tunnels directly into the sapwood, where they may branch in several directions. The larval mines extend longitudinally through the branch and may reach a length of 7 in. For the most part, the species work in dry wood of broken branches and are hence of little economic importance.

The California hardwood bark beetle, *M. hirtellus* Lec., dark reddish brown, 3 mm. in length, attacks the dry, hard wood of twigs of many flowering shrubs and trees in the San Francisco Bay region of California, in the redwood belt, and northward into Oregon. It has been taken from various species of *Salix, Myrica, Acer, Alnus, Arbutus, Umbellularia,* and *Ceanothus.* At San Jose, Calif., in 1927, it caused the Pacific Telephone and Telegraph Company considerable trouble by boring holes through lead telephone cables, allowing water to soak in, and causing short circuits on the telephone line.

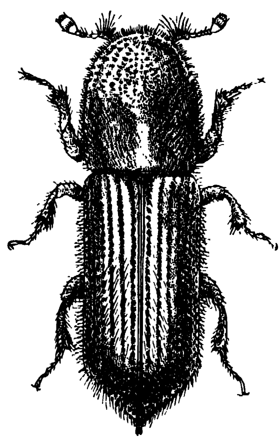

Fig. 51. The California hardwood bark beetle, *Micracis hirtellus* Lec. × 18.

M. swainei Bl., dark reddish brown, from 2 to 2.1 mm. in length, is widely distributed through the southern part of the United States, being recorded from Maryland; West Virginia; Washington, D. C.; Louisiana; Texas; Arizona; and southern California, breeding in redbud, *Cercis canadensis,* and in willow, *Salix. M. populi* Sw. was taken by Dr. Swaine from shoots of *Populus* at Ithaca, New York. *M. suturalis* Lec. is found in Illinois, Michigan, Virginia, Pennsylvania, the District of Columbia, Ohio, West Virginia, and Maryland, breeding in *Cercis, Juglans,* and *Asimia. M. meridianus* Bl. breeds in redbud in Mississippi, Virginia and the District of Columbia. *M. lignator* Bl., dark reddish brown, 2.83 mm. long, breeds in black oak in Arizona.

In the subgenus *Micracisella* Bl. the adults work in the pith or twigs. *M. opacicollis* (Lec.) is a common species in the southeastern section of the country, breeding in oak, maple, and southern cypress. It has been recorded from Florida, Mississippi, Texas, Virginia, District of Columbia, Maryland, New York, Massachusetts, Michigan, Kansas, Arkansas, and West Virginia. *M. nanula* (Lec.) breeds in *Quercus* and *Persea* in Florida, Georgia, South Carolina, and Texas.

The genus *Phthorophloeus* Rey is represented in the United States by eight described species. These are small bark beetles with very loosely jointed antennal clubs. They all appear to be monogamous and confine their attacks to the bark of deciduous trees, where they

construct egg galleries of the double-transverse type. They are sometimes of considerable economic importance. *P. frontalis* (Oliv.), 1.8 to 2.2 mm. long, attacks native mulberries throughout the region east of the Rocky Mountains. It prefers the branches and trunks of weakened trees or the trunks and stumps of felled trees. *P. dentifrons* Bl., 1.2 to 1.6 mm. long, closely allied to *P. frontalis*, is a common species found in Mississippi and Kansas breeding in the broken limbs of hackberry. *P. piceae* Sw., 2 to 2.25 mm. in length, breeds in white spruce in northeastern United States and in Canada.

The genus *Procryphalus* Hopk. includes seven species of small, dark bark beetles with a four-segmented antennal funicle. They breed in the bark of various deciduous trees, such as maple, willow, and aspen. They are of little or no economic importance. *P. aceris* Hopk., 1.55 mm. long, elongate, dark brown with darker pronotum, attacks *Acer macrophylum* in Oregon. *P. salicis* Hopk., 1.65 mm., light brown, elytra lighter, pronotum darker, is found in *Salix* sp. in the Black Hills of South Dakota. *P. populi* Hopk., 2.15 mm., dark brown, pronotum with sides strongly rounded, breeds in quaking aspen in Colorado.

The genus *Pseudopityophthorus* Sw. includes very small, hairy, cylindrical, dark reddish-brown to black bark beetles from 1.4 to 2.5 mm. in length, which attack the trunk, branches, and twigs of various hardwoods, particularly the oaks. At times they are very destructive to oaks in failing health and are able to kill the trees in a few weeks. Normally, however, they breed in countless numbers in injured, felled, or recently killed trees and in the dead branches and twigs on otherwise healthy trees.

The typical egg galleries are made between bark and wood, grooving both. At the juncture of the entrance tunnel and the wood two short, longitudinal galleries or turning niches are constructed, while the main egg galleries are excavated transversely on either side of the entrance. The larval mines run longitudinally or at right angles to the egg galleries, and the pupae form in longitudinal cells at the ends of the larval mines in the inner bark. When the new brood emerges, numerous round pinholes are left in the bark as each beetle uses a separate exit hole.

The western oak bark beetle, *Pseudopityophthorus pubipennis* (Lec.), is the very common western form which attacks various oaks and ash. These beetles frequently kill oaks which are in an unhealthy condition and at times breed in enormous numbers in cordwood. There appear to be two or more generations a year, with the broods overwintering under the bark in the stages of larvae and adults. In the Eastern states *P. minutissimus* (Zimm.) breeds in the dying and dead branches

of oak, beech, hazel, and dogwood and is widely distributed from Quebec to Florida. *P. pruinosus* (Eich.) attacks and kills small to large red oaks and probably works in other oaks and many other trees that are injured, felled, or dying. It is distributed from New York to Florida and Mississippi. *P. asperulus* (Lec.) works in various species of *Quercus* in the Atlantic and Gulf states. It is also recorded from *Castanea* and *Betula*. *P. agrifoliae* Bl. works in live oak in California.

The genus *Pseudothysanoes* Bl. includes *P. hopkinsi* Bl., which is black with the summit of the pronotum reddish brown, 1.31 mm. long, and is described from Ventura County, California, breeding in *Salix*. *P. sedulus* Bl., black, 1.5 mm. long, was reared from oak in Arizona. *P. gambetti* Bl., very dark brown to almost black, 1.37 mm. in length, breeds in oak twigs in Arizona and New Mexico. *P. barberi* Bl. is very dark reddish brown, 1.71 mm. long, and is found on oak in Arizona. *P. drakei* Bl. breeds in the bark of basswood limbs in New York. *P. rigidus* (Lec.) breeds in dead basswood in Michigan and is also recorded from West Virginia. *P. lecontei* Bl. breeds in oak, *Castanes*, *Celtis*, *Ostrya*, and *Juglans* in the District of Columbia, West Virginia, and North Carolina.

The genus *Renocis* Casey is represented by two species, a small brown bark beetle, *R. heterodoxus* Csy., which works in the limbs of mountain mahogany, *Cercocarpus parvifolius*, in Oregon, Nevada, and California; and *R. penicillatus* Bruck, which breeds in the small branches of *Rhus integrifolia* in southern California.

The genus *Spermatoplex* Hopk. includes one species, *S. rhizophorae* Hopk., a small, dark, reddish-brown bark beetle with a five-segmented antennal funicle and club with two procurved sutures on the posterior face, 2.85 mm. in length, which was found in mangrove, *Rhizophora mangle*, in Florida.

The genus *Stephanoderes* Eich. includes about thirty species of very small, stout bark beetles closely related to *Hypothenemus*. The egg galleries and larval mines are constructed in the bark, the wood, or the pith. Nearly all are found in the Southeastern states breeding in the dying and dead branches of various broadleaf trees. They are of little or no economic importance from the forester's viewpoint. For further information concerning them the reader is referred to works by Hopkins (1915, *Report* 99) and Blackman (1922, *Mississippi Agricultural Experimental Station Bulletin* 11).

In the genus *Thysanoes* Lec. the adults have the posterior end of the elytra rounded instead of acuminate. In habit they are similar to *Micracis*, in that both larvae and adults feed within the wood. The entrance tunnel, after penetrating the wood for a short distance, opens into a slightly enlarged nuptial chamber from which the egg

galleries radiate. The species is of slight economic importance. *T. fimbricornis* Lec. is the most common species of the genus in the eastern section of the United States. It breeds in hickory, black oak, redbud, and acacia and is recorded from Pennsylvania, Mississippi, Florida, West Virginia, Texas, North Carolina, Virginia, and the District of Columbia. *T. xylophagus* Bl., dark brown to almost black, 2 mm. long, breeds in oak in Arizona and New Mexico. *T. lobdelli* Bl. is found in maple and oak in Mississippi and Georgia. *T. berchemiae* Bl. has been taken from rattan vine, *Berchemia scandens*, and from *Ulmus* in Mississippi, Texas, Virginia, and Florida.

The genus *Trypophloeus* Fairm. is represented in the United States by five species of very small bark beetles with five-segmented antennal funicle. They breed in dying or dead bark of willow, aspen, poplar, and alder and are of little or no economic importance. *T. salicis* Hopk., 1.7 mm. long, dark brown, pronotum darker, breeds in willow, *Salix* sp., at Del Monte, Calif. *T. populi* Hopk., 2.05 mm. long, attacks *Populus tremuloides* in Arizona.

THE AMBROSIA OR TIMBER BEETLES

One large group of scolytid beetles has the habit of excavating their mines directly into the sapwood and heartwood of various trees, making so-called "pinholes." These are known as the ambrosia beetles because of their habit of propagating, upon the walls of their galleries, certain fungi which are consumed by both adults and larvae and are called "ambrosia." This is one group of beetles that care for their young in much the same manner as do certain forms of social Hymenoptera—bees, ants, wasps, etc. The adult beetles carry in the fungus spores, prepare beds for them, and tend the gardens, which are fertilized by larval excrement. Each species has its own special variety of fungus. There must be a certain amount of sap present in the wood, or the fungus will not grow, and as a consequence dying trees and wine barrels, vinegar casks, and other wood saturated with fermenting liquors are particularly favored for attack. Each colony will continue in a given host as long as conditions are right for the growth of their fungus food but will abandon a tree as soon as it begins to dry out. Most trees attacked by these beetles are sickly, and the wood in a fermenting condition before the attack is made. A few species, however, enter healthy trees but work only in small colonies and hence do little damage. The principal injury is caused by the pinhole galleries and the staining of the wood around the galleries by the ambrosial fungus. This injury at times renders lumber practically worthless.

The Wide-headed Ambrosia Beetles.—The family Platypodidae is essentially tropical. In Central America they are abundant, but only a few species, all belonging to the genus *Platypus* Herbst., extend northward into the United States.

Although the species of this genus are not numerous in the United States, they are the largest and frequently the most destructive of the ambrosia-feeding timber beetles, since their mines usually penetrate to the very heart of the attacked tree. All are wood borers, usually confining their attack to weakened trees where they work in both the trunk and the limbs. They are easily recognized by their broad heads, slender cylindrical bodies, projecting wing covers, and long slender tarsi.

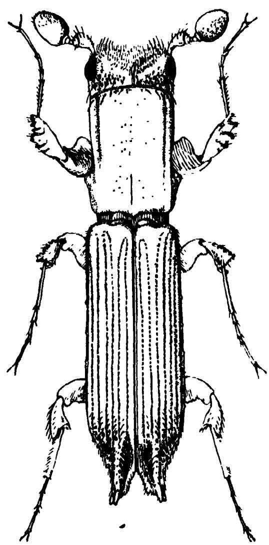

FIG. 52. Wilson's wide-headed ambrosia beetle, *Platypus wilsoni* Sw., male. × 10.

The adults excavate cylindrical mines, from a few inches to a foot in length, extending directly through the bark into the sapwood and heartwood of large or small trees. Eggs are deposited loosely in small clusters in the galleries, each female depositing from 100 to 200 eggs. There are usually several males and females in each gallery, and the males are constantly at war with one another over the possession of some female. The young larvae wander freely about the mines, feeding upon the ambrosia fungus, and reach maturity in five or six weeks. When full-grown, they excavate cells at right angles to the main gallery in which to transform to pupae and adults. These cells are parallel with the grain of the wood and are often placed in groups of eight or ten or more. Only one species is found in the northwestern section of the country, but several are found in the Southeast and Southwest.

Wilson's wide-headed ambrosia beetle, *Platypus wilsoni* Sw., is a long, slender, brown, shining beetle, 5.5 mm. in length, clothed with long, yellow hairs. The sexes are readily distinguishable in that the female has the posterior end more or less blunt, while in the male the elytra are divergent and spined.

Dying, weakened, recently dead, and sometimes healthy timber of all Pacific Coast conifers (except the cupressineous group) are attacked. The species is known to be distributed from British Columbia to California.

Platypus compositus Say in the adult stage is light reddish brown, 4.5 to 5 mm. in length. A great variety of trees are attacked by it,

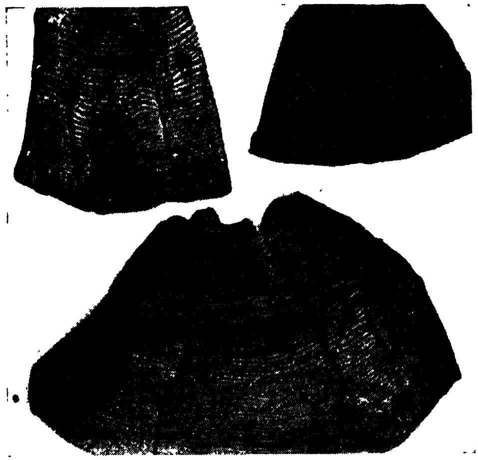

FIG. 53.—Egg tunnels of Wilson's wide-headed ambrosia beetle, *Platypus wilsoni* Sw., in wood of *Abies concolor*. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Photo by Miller.*)

including hickory, pecan, yellow birch, cottonwood, weeping willow, sweet gum, sour gum, magnolia, and red oak, and apparently almost any of the broad-leaved trees as well as recently felled and girdled cypress. It is found through the Southeastern states and as far north as Delaware and southern Illinois.

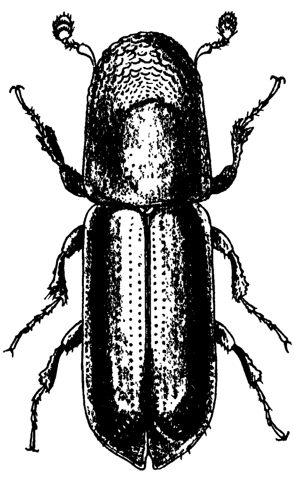

FIG. 54.—The western hemlock wood stainer, *Gnathotrichus sulcatus* (Lec.). × 17.

P. flavicornis (Fabr.) is dark reddish brown and from 5.5 to 5.9 mm. in length in the adult stage. It is nearly as widely distributed as the above but is found most commonly in the pines and other conifers, where it completely riddles the sapwood and heartwood of the lower portion of the trunk. *P. quadridentatus* (Oliv.) in the adult stage is 4.25 mm. in length, reddish brown, with the posterior part of the elytra nearly black. It is not abundant but has been reported from West Virginia, Florida, and Texas, where it works in white oak, red oak, black oak, and chestnut.

The Wood Stainers.—The species of the genus *Gnathoirichus* Eich. are all small, cylindrical, dark brown or black, wood-boring

ambrosia beetles, with the thorax long and the sexes similar in appearance. The males can be distinguished from the females by the character of the antennal club and by the stronger development of the tubercles or teeth at the end of the elytra.

The adults tunnel in the sapwood and often in the heartwood of injured, dying, and recently dead pines, firs, spruces, hemlocks, and larch. Occasionally they will be found working in living, apparently healthy trees. They enter through the bark and penetrate the wood, making a cylindrical tunnel about 1 mm. in diameter. After attaining

FIG. 55.—Pupa and adults of the western hemlock wood stainer, *Gnathotrichus sulcatus* (Lec.), in pupal cells in Douglas fir. × 4.

a depth of two or three inches the gallery may, and usually does, branch in a horizontal plane in several directions. One of the secondary branches usually parallels an annual ring. A copious amount of fine white boring dust is thrown out of the gallery and collects in crevices of the bark or at the base of the tree. Elongate eggs are deposited in cuplike niches cut by the female both above and below the main gallery, each niche containing a single egg. The larva hatching from this egg lengthens its niche gradually, grows, and transforms to the adult within this cradle. The food of both larvae and adults is a species of ambrosia fungus which grows upon the walls of the tunnels. The broods reproduce and continue to extend their galleries as long as the wood of their host is in the proper state of moisture for growing the fungi. There are usually two or more

broods each year, but these are not regular, since larvae, pupae, and adults are present within the galleries at almost any season of the year.

The eastern pine wood stainer, *G. materiarius* (Fitch), lives in pines, spruces, and larch throughout the eastern United States and Canada. *G. denticulatus* Bl. breeds in various pines and firs in New Mexico and Arizona.

FIG. 56. Egg tunnels of the western hemlock wood stainer, *Gnathotrichus sulcatus* (Lec.), in Sitka spruce. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Photo by Miller.*)

The western pine wood stainer, *G. retusus* (Lec.), 3 mm. long, blackish brown with yellow appendages, is the species commonly found mining the sapwood of many species of pine, hemlock, Douglas fir, and some true firs over the greater part of the forested areas of the western United States and Canada. *G. alni* Bl. breeds in alder along the coast of Oregon and Washington.

The western hemlock wood stainer, *G. sulcatus* (Lec.), is very similar to *retusus* in appearance, and its habits and methods of work are essentially the same. It is generally distributed through the forests of the Pacific Coast and Rocky Mountain regions, where it attacks the wood of spruces, fir, Douglas fir, hemlock, pine, redwood, and cedar. *G. aciculatus* Bl. is similar to the above and is found from South Dakota south through the Rocky Mountains to Arizona and New Mexico, feeding on Douglas fir, fir, and various pines.

The genus *Trypodendron* Steph. (*Xyloterus* Erich.), comprises small, stubby, dark-colored ambrosia beetles often marked with lighter stripes, with roundish prothorax and more or less shining elytra. Their tunnels penetrate the sapwood and frequently the heartwood of weakened, injured, dying, or felled trees, where they branch in several directions, and the larval cradles are arranged in series both above and below these main galleries. Ambrosial fungus furnishes the food supply, and the stain from this fungus discolors the wood for some distance from the mines. The male and female work together in constructing the galleries. Eggs are deposited in shallow niches cut out by the female along the sides of the tunnels and

usually well back from the entrance. The larvae extend these niches into short tunnels or larval cradles and remain in these until they pupate and change to the adult form. Both conifers and broadleaf trees are attacked, and the species are found throughout the United States and Canada, although they are typically northern forms.

T. scabricollis (Lec.), dark reddish brown, from 3.1 to 3.6 mm. in length, is reported as attacking pine and hemlock in New York, Pennsylvania, District of Columbia, West Virginia, and New Mexico and was taken by Blackman from loblolly pine in Mississippi.

The poplar timber beetle, *T. retusum* (Lec.), constructs its pinhole galleries in the wood of poplar and aspen, probably throughout the range of these trees in the United States and Canada, although it is most common in the northeastern United States and eastern Canada.

The birch timber beetle, *T. betulae* Sw., works in the wood of birches near the coast in eastern Canada and southward to New York.

The two-striped timber beetle, *T. bivittatum* (Kby.), 3 mm. long, is a stout, shining, dark bronze-colored beetle with two pale longitudinal stripes on the elytra, antennae, and legs and a band on the pronotum yellowish brown. This species is found throughout the United States and southern Canada and attacks most of our North American conifers, including species in the genera *Abies*, *Pseudotsuga*, *Pinus*, *Picea*, *Tsuga*, and *Larix*. A similar if not identical species occurs in *Sequoia* and *Juniperus*. It is often a rather serious pest in recently felled timber, as well as in injured, dying, and fire-scorched trees. *T. cavifrons* (Mann.) is a similar species found mining the wood of pine, alder, spruce, birch, and cedar in British Columbia west to the Rockies and south to California.

The ponderosa pine timber beetle, *T. ponderosae* Sw., works in ponderosa, Engelmann spruce, Douglas fir, alpine fir, and mountain hemlock in the high mountains of British Columbia and south to Oregon; it is similar in size and shape to *bivittatum* but is a deep, shining black with an indefinite area on the disk of the pronotum and very dark reddish-brown elytra; 3 mm. long. *T. borealis* Sw. lives in white spruce in north-central Canada. *T. rufitarsis* (Kby.), similar to *bivittatum*, is distributed across Canada and the northern United States in spruce, jack pine, and lodgepole pine.

The genus *Pterocyclon* Eich. (*Monarthrum* Kirsch) includes a group of four species of ambrosia or timber beetles which work for the most part in hardwoods—oak, hickory, birch, beech, maple, various fruit trees, and other deciduous trees—although they are also found in conifers. Like other ambrosia beetles, the adults bore directly through the bark into the sapwood, making pinholes which greatly weaken the lumber, stain it badly, and render it unfit for

commercial use. Their egg tunnels, after entering the wood for a short distance, branch in several directions in the horizontal plane. *Larval cells or cradles are then constructed at regular intervals, both above and below the egg tunnels, in the vertical plane.* The adults are small, *dark-brown to black cylindrical beetles from 2 to 4 mm. in length.*

The large California oak ambrosia beetle, *Pterocyclon scutellare* (Lec.), is elongate, cylindrical, dark brown, 3.5 to 4.1 mm. in length. The female is readily distinguished by a tuft of long hairs on the margin of the antennal club, a well-developed epistomal process bifid at the apex, and a plano-convex declivity. The male lacks the long hairs of the antennal club and has a broad epistomal process and a convex declivity. In both sexes the elytra are brownish at the base but blacker toward the tips; the antennae are yellowish; the funicle two-segmented; and the much compressed club has two deep, straight, transverse sutures. The adult male bores directly through the outer bark into the solid wood, where a central nuptial chamber is formed; from here, with the assistance of the females, the secondary galleries are constructed, first branching into two, then three, and then four directions but more or less concentric with the annual rings at a depth of from 4 to 6 in. From these secondary branches the larval cells are excavated at right angles and parallel to the grain of the wood. Eggs are placed in niches on alternate sides of the burrow, sometimes opposite, and the larvae upon hatching gradually increase the size of their cells as they grow. The food of both larvae and adults is a fungus, probably a species of *Monilia*, which they propagate in the galleries and tend with great care. If for any reason the larvae are unable to consume their food supply as rapidly as it forms, it is apt to choke the galleries and smother the occupants. It requires from three to four months for the beetles to attack and rear a brood, and consequently there are two and possibly three generations each year, with considerable overlapping of broods. This species confines its attack to dying or badly weakened oaks and freshly cut logs and has been recorded from *Quercus agrifolia*, *Q. californica*, and *Q. wislizenii*. It is distributed from Oregon to southern California.

The smaller California oak ambrosia beetle, *Pterocyclon dentiger* (Lec.), is a much smaller species 2 mm. in length which is often found working in the same trees with the above species. It is found in California attacking live oak, *Q. agrifolia*, and white oak, *Q. lobata.*

In the eastern states *P. fasciatum* (Say), 2.4 to 2.7 mm. long, reddish to dark brown, with basal three-fourths of the elytra straw yellow, and densely hairy behind, attacks maple, beech, and hickory and many other deciduous and coniferous trees in the eastern United

States and Canada. *P. mali* (Fitch), 2.2 to 2.5 mm. long, shiny black and slender, attacks apple, oak, birch, and other deciduous trees in the eastern United States and Canada.

Beetles of the genus *Corthylus* Erich. are short and stout, with the thorax almost as large as the abdomen. The surface is smooth and shining, the color deep black. The sexes are alike. The species work mostly in twigs, excavating spiral tunnels, while some work in the sapwood of large trees. Three species are found in the eastern states with no western representative.

The columbian timber beetle, *Corthylus columbianus* Hopk., attacks the sapwood of perfectly healthy trees, apparently without seriously impairing their health. The galleries are later abandoned and grow over. The holes eventually come to light if the tree is cut into lumber and will seriously reduce the lumber's value. Successive generations may attack the same tree. The adult beetle bores straight through the bark into the wood. The tunnel branches after entering the wood, and the branch tunnels follow the sapwood around the tree. The larvae are reared in separate cells placed alternately along the sides of the main gallery. The number of young raised by each pair of beetles seems to depend upon the host; in oak and beech there are seldom more than twelve young, while in yellow poplar twice as many may be found. Winter is passed as adults in the galleries. In the spring the colonies leave the old galleries and dig new ones to raise another brood. The fungus grown in the galleries as food stains the wood a deep black and reduces its value. This beetle is distributed from Massachusetts south to Florida.

The pitted ambrosia beetle, *C. punctatissimus* (Zimm.), is a very small, dark-brown to black ambrosia beetle which works in the stems of shrubs and small trees near the ground and causes them to break off. Rhododendron, sugar maple, sassafras, dogwood, hazel, huckleberry, ironwood, water beech, and other shrubs are attacked, and the beetle is widely distributed through the eastern United States.

The genus *Xyloterinus* Sw. (*Trypodendron* Steph.) includes only one species, found in the eastern United States and Canada. *X. politus* (Say), brown to black with reddish-brown elytra and very fine pubescence, from 2.8 to 3.5 mm. in length, is an ambrosia beetle found in a wide variety of trees, including birch, beech, maple, oak, hickory, ash, chestnut, alder, magnolia, and also conifers such as spruce, pine, and hemlock. The beetles attack injured, sickly, or cut trees in which there is still sufficient sap to insure the growth of their ambrosial fungus. After penetrating the wood the mines fork or branch in several directions, and the larvae develop in small niches or cradles constructed at right angles to the egg galleries. As with other ambro-

sia beetles, the fungus stains the wood and serves to decrease its commercial value.

Genus *Anisandrus* Ferr. are small, stout, cylindrical, ambrosia-feeding pinhole borers. The males are small and wingless, while the females are larger and winged. They are all dark brown to black in color and vary in length from 0.82 to 3.7 mm. Their egg tunnels enter directly into the sapwood of various broadleaf trees, where they branch in a vertical plane. The larvae live free in the egg tunnels and do not construct separate larval cradles or mines. They breed for the most part in deciduous and broadleaf trees but may attack conifers as well. Weakened or unhealthy trees are preferred, but apparently healthy trees may also be attacked and damaged.

The pear blight beetle, *Anisandrus pyri* (Peck), is the American representative of the European shot-hole borer, *A. dispar* (Fabr.). The males are about 2.2, and the females 3.5 mm., in length. They are very destructive to the wood of many injured and weakened orchard, shade, and forest trees. Young trees may be killed by them within a few months. They are found in almost all parts of the United States. *A. obesus* (Lec.), stout and black to dark brown, sparsely clothed with long gray hairs, females 3 to 3.25 mm., males 1.65 to 1.75 mm. long, is closely allied to the above. It is found living in birches, oaks, maples, and beech in the eastern United States and eastern Canada. *A. minor* Sw., females 2.25 to 2.5 mm., males 1 to 1.2 mm. long, is also found in dying maples and beech in eastern Canada and eastern United States. *A. populi* Sw., allied to *obesus*, male 1.6, female 3.2 mm. long, is found in eastern Canada in the trunks of unthrifty and dying poplars.

Genus *Xyleborus* Eich. includes a large number of small pinhole borers or ambrosia beetles which attack a wide assortment of fruit, shade, and forest trees. Dying, sickly, felled, or weakened trees or dead areas and wounds in living ones are selected for attack.

The female starts the attack by boring through the bark into the wood and constructing several branching galleries in which the eggs are deposited. After the entrance burrow is started, she is joined by other females which extend the galleries deep into the sapwood and heartwood, assist in expelling the boring dust, and help to guard the entrance. The primary gallery usually extends into the heartwood before eggs are deposited.

When the primary gallery is completed, beds are made for the propagation of the ambrosia fungus upon which the brood is to feed. This fungus, when viewed under the microscope, appears like a miniature forest of bamboo, very light in color, and each stalk is surmounted by a small ball (conidium).

The first eggs, which are few in number (five to ten), are laid as soon as the fungus gardens are started. They are placed without any protection near the end of the main or lateral galleries or loosely in the egg cavity. These hatch in from 6 to 10 days, and the young larvae begin feeding upon the ambrosia. After the larvae of the first brood have attained considerable size there is a second deposition of eggs, and so on at intervals until a large number of larvae have been reared.

The larvae help extend the burrows or enlarge the brood cavity, and their excrement is used as beds for the fungus gardens. Any surplus is either removed from the mines by the adults or packed in side galleries with any dead individuals of the colony or remains of their enemies.

Growth and pupation occur in the galleries and not in special cells, as in the case of some other genera. A generation from eggs to adults may require about five weeks during the summer. Most of the brood, in a ratio of about 15 or 20 to 1, will be females, and these will be fertilized by the males of the same brood. The males are usually smaller than the females; sometimes they are wingless and spend their entire lives in the galleries, where they remain after the fertilized females have left until they are smothered by the growing fungus which they are unable to consume.

The females pass the winter in the brood chambers. Early in the spring they emerge and start their attacks. During the spring and summer eggs and all stages of larvae, pupae, and adults will be found in the galleries. The galleries and chambers are constantly being extended to care for the enlarging family. Families may leave the colony from time to time to start new colonies in the same or different trees, but the original colony will continue to work in the old tree as long as the moisture content of the wood is favorable to the growth of their particular fungus.

The lesser shot-hole borer, *Xyleborus saxeseni* (Ratz.), is a very common species in Europe, where it attacks nearly all species of forest trees, both conifers and hardwoods. A species in every way similar to this is found throughout North America and is also reported from Japan. The adult female is from 2.3 to 2.5 mm. in length, yellow-brown to black; the male is slightly smaller. The species is characterized by having the scutellum indistinct and the apex of the elytra obtuse, with an acute marginal granule on each side. The galleries consist of small, round entrance tunnels leading horizontally into the sapwood and ending in an enlarged leaf-shaped cavity in which the fungus is grown and the larvae feed.

This species is often confused with the eastern *X. xylographus* (Say) but it is very distinct in adult characters as well as work. A wide

variety of hosts are attacked, including fruit trees and ornamentals as well as deciduous and coniferous forest trees. In the Bureau of Entomology collection at Berkeley, Calif., are specimens collected by Burke from *Alnus rhombifolia* at Placerville and by Herbert from *Cupressus macrocarpa* at Mayfield. *X. quercus* Hopk. was described from Mississippi in oak. *X. pecanis* Hopk. works in yellow birch, sweet gum, peach, and pecan in Mississippi. The galleries are of the simple, unbranched type, consisting of an enlarged cavity. Apparently the life cycle is completed in slightly less than two months. *X. arbuti* Hopk. is similar to *saxeseni* except for having a shining declivity. It was described from *Arbutus menziesii* found at Walker, Calif. *X. affinis* Eich. has been reported from dying hickory, pecan, and oak in West Virginia and Mississippi. *X. xylographus* (Say) is the very common eastern species which probably attacks all hardwoods from North Carolina north to New York and west to Wisconsin. Similar species found in a great variety of hosts throughout the western states have been referred to this species but many of them may be distinct. Van Dyke reports it from beech, larch, pine, hickory, oak, maple, hemlock, and spruce. The galleries are reported as consisting of branching egg galleries, in which the larvae live and feed upon the ambrosial fungus without constructing an enlarged cavity or larval cradles. *X. inermis* Eich., probably identical with *xylographus*, is reported by Hopkins from chestnut in West Virginia. *X. scopulorum* Hopk., very similar to the above, was described from *Pinus scopulorum* in South Dakota. Hopkins also identified specimens from *P. coulteri* in California as this species. A species commonly found in ponderosa pine killed by bark beetles in California and Oregon is in every respect similar. These work only in punky, decaying wood or in dead trees, making numerous small, round tunnels branching horizontally through the sapwood. They are of only very secondary importance. *X. fitchi* Hopk., allied to *xylographus*, was described from pine in Long Island.

X. canadensis Sw., allied to *xylographus*, is a rare species found in Quebec in oak stumps. *X. nyssae* Hopk. was described from *Nyssa* sp. in South Carolina. *X. fuscatus* Eich. has been reported from the southeastern states as far north as New Jersey and west to Texas, as well as from Guatemala and Colombia. The host plants include *Quercus, Hicoria, Castanea, Juglans,* and *Pinus.* Blackman also found it in Mississippi in willow, oak, yellow birch, and red maple. The galleries are of the compound ambrosial type and are very complicated, with many branches both under the bark and in the sapwood. *X. confusus* Eich., which has been reported from Chile and Venezuela, was found by Blackman in the base of a longleaf pine in Mississippi.

The hickory timber beetle, *X. celsus* Eich., probably occurs throughout the Eastern section of the country following the distribution of its host plant, the various species of *Hicoria.* The beetles breed in dying or dead hickories and are very common in trees killed by the hickory bark beetle. The galleries are of the branched ambrosial type. The entrance tunnel leads into an enlarged nuptial chamber in the sapwood from which branch many secondary galleries, for the most part in a horizontal plane. Some of these cross one another and may penetrate deeply into the heartwood. They cause rapid deterioration of dead or felled hickories.

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CHAPTER VI

THE BEETLES (*Continued*)

THE FLATHEADED AND THE ROUNDHEADED BORERS

THE FLATHEADED BORERS

The flatheaded borers, family Buprestidae, are small to large, often beautifully marked, metallic-colored, oval beetles. The white, legless, hammerheaded or flatheaded larvae give the common name to the family.

Many of the beetles feed to some extent on the foliage or bark of the twigs of the host or some other plant. Where they are common they sometimes cause considerable defoliation to individual plants.

All the larvae are miners in the tissues of plants. Most species mine the inner bark or wood of trees and shrubs; one mines the hard, woody cones of coniferous trees; while some work between the upper and lower surfaces of leaves. The mining in the tissues of the plant may cause the death of a part or the whole of the plant or, in the case of a forest tree, the injury or total loss of the wood which is the principal product.

The eggs are laid singly or in a group on the surface of the leaf, bark, or wood or are tucked into a hole or crevice in the bark or wood or placed under the bark on the surface of the wood. Part of the larval stage is passed in a mine in the leaf, bark, or wood; and part, the pupal or resting period, in the so-called pupal cell at the end of the mine. Some leaf miners, however, appear to spend the larval resting period and the pupal period in the soil.

The beetle usually emerges from the pupal cell during the spring or summer, feeds for a short time, mates, and lays its eggs soon afterward. The eggs hatch in from 10 to 50 days, and the young larvae start mining. The larval stage in some leaf miners is over in a month or more, while in some wood borers it may last for several years. Usually, however, there is one complete generation every year or at most every two years. With most species the pupal stage is over in a month, but there is some evidence that a few species pass the winter as a pupa. Many species overwinter in the adult stage in the pupal cell, and it has been noted that some hibernate over the winter after emergence. The beetles of most species, however, die within a month or two after emergence.

The bark borers or cambium borers usually mine the inner bark and outer wood of dying or dead plants. Some, however, will attack and kill perfectly healthy cambium, either of a part or of the whole plant. Certain of the species that mine the living bark do not kill it but cause the formation of abnormal growths called galls. Others kill part of the living tissue, which soon heals over and causes a "gum spot," "pitch pocket," "check," or other defect to form in the wood. Some borers mine the pitchy wood of trees "boxed" or "scarred" in turpentine operations and not only destroy considerable timber because their mines spoil it for high-grade uses but weaken the trunk so that the tree is blown over by the wind, and its life as a turpentine producer considerably shortened. Others mine only the wood of dying and dead trees but do much damage because their work injures much valuable material. Some wood borers that mine stumps, branches, and old dead trees are beneficial, because their mines increase the rate of disintegration in such material which is useless to man. Some damage by flathead defoliators may be prevented by spraying or dusting the plants to be protected with an arsenical or other poison. Cambium miner damage may be prevented or mitigated by the use of mechanical protectors, repellent sprays, or through forest management and sanitation by the destruction or treatment of infested material or material apt to become infested. Wood-borer damage is prevented by the practice of forest sanitation, which eliminates favorable breeding material; and mitigated by the use of injured material for the purposes for which it is best suited.

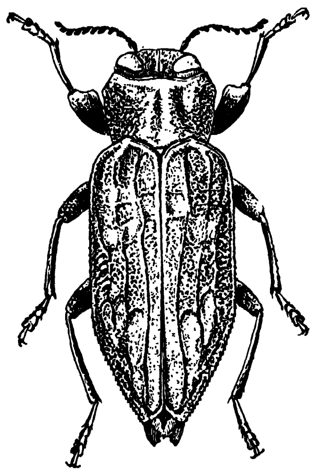

FIG. 57.– The flatheaded apple-tree borer, *Chrysobothris femorata* (Oliv.). × 3.5.

A few representatives of the most important genera are listed here

The genus *Chrysobothris* Esch. contains some of the more common and injurious members of this family. They are small to medium-sized beetles, usually not conspicuously colored.

The flatheaded apple-tree borer, *Chrysobothris femorata* (Oliv.), is probably the best known flathead in America. It is injurious to shrubs and shade, ornamental and fruit as well as forest trees. The adult is an oval, flattened, dark grayish-bronze beetle, about 10 mm. in length by 5 mm. in breadth. The wing covers are marked with two wavy, depressed bands of a lighter color. The forelegs of the males are armed with several small teeth, and their heads are green.

The eggs are pale yellow, flattened, disklike, wrinkled, and about 1 mm. in diameter. The full-grown larva is yellowish white and about 25 mm. long. The first segment is large and round, and the plates are well-developed. The apex of the V on the dorsal segment extends to the anterior margin of the rugose area. The pupa is about the same size as the adult, white at first but later taking on the colors of the adult.

The beetles are found from about the first of May until the middle of August. They fly about in the warm sunshine or run rapidly over the bark of living, dying, and dead trees. The eggs are usually laid in crevices or under flakes of the bark at the edge of wounds or on dying trees. Sometimes they are laid on the smooth bark. They hatch in from 12 to 20 days, and the young larva bores through the bottom of the shell down into the bark.

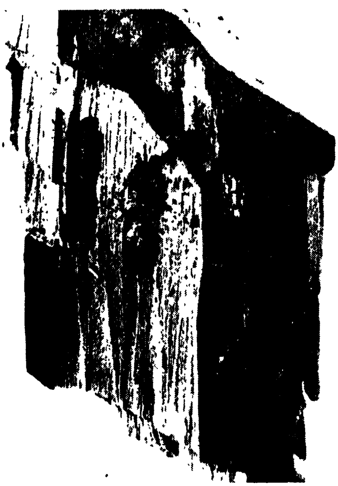

FIG. 58. Pupa and recently transformed adult of *Chrysobothris sylvania* Fall in their cells in Douglas fir.

Feeding as it goes, the larva excavates a mine several inches long in the inner bark and outer wood. The mine is narrow at the start but broadens considerably as the larva develops and increases in size. Usually by late summer full growth is reached, and the larva forms a cell in the outer wood into which it seals itself by a plug of borings, rests awhile, and then pupates and transforms to a beetle.

The larva usually rests over the winter in the pupal cell before pupating and transforming; sometimes it rests over two winters.

The pupal stage lasts from two weeks to two months, depending upon climatic conditions, and the young beetles pass a week or two in the pupal cells before emerging, mating, and laying eggs to start a new generation.

Chrysobothris femorata (Oliv.) occurs in practically every state in the Union and in Canada. The greatest damage is done to newly planted trees, many of which are attacked and killed the first year after they are transplanted.

The first evidence of an attack is usually a wet spot on the bark. Later there is a sunken area which cracks and shows the mines filled with boring dust beneath.

Control in forest trees is generally not necessary. In ornamental and other trees it consists in keeping all breeding places, such as dead

and dying trees and prunings, cleaned up; maintaining all trees in good condition by cultivation, irrigation, etc.; and sometimes, as in the case of newly planted trees, protecting them by the use of a mechanical tree protector.

The Pacific flatheaded apple-tree borer, *C. mali* Horn, is slightly smaller than *C. femorata* Oliv. The forelegs of the male are not toothed but expanded at the tips. The species injures and kills many shrubs and fruit, shade, and ornamental trees in the Pacific states.

The cedar flatheaded borer, *C. nixa* Horn, is an enemy of *Juniperus communis* in Yellowstone National Park; *J. occidentalis* in Oregon; and incense cedar, *Libocedrus decurrens,* and Monterey cypress, *Cupressus macrocarpa* in California.

The southwestern juniper flatheaded borer, *C. texana* Lec., attacks several species of juniper in the southern Rocky Mountain states.

The mesquite flathead, *C. octocola* Lec., riddles the wood of injured, dying, and dead mesquite, *Prosopis juliflora,* and paloverde, *Cercidium terreyanum,* in the Southwest, often causing severe injury to posts and firewood.

The California flathead, *C. californica* Lec., mines the exposed roots of various pines in California.

Numerous other species of *Chrysobothris* attack various species of deciduous and coniferous trees and cause similar damage. Some act as bark looseners and damage rustic work of various kinds. Only a few are listed here.

In the eastern states, *C. blanchardi* Horn occurs in pines and larch; *C. pusilla* Cast. in spruce and fir; *C. sexsignata* Say in hardwood trees. *C. dentipes* Germ. is generally distributed throughout the United States in pines and larches. In the West we find *C. caurina* Horn, *C. purpurifrons* Mots., *C. dolata* Horn, and *C. monticola* Fall attacking pines; *C. sylvania* Fall in Douglas fir; *C. viridicyanae* Horn in juniper and cedar, and *C. carinipennis* Lec. in pines, larch, and Douglas fir. *C. ignicollis* Horn attacks junipers, and *C. ludificata* Horn attacks pines in the Southwest. *C. trinervia* Kby. is found in pine and spruce in Alaska and the Hudson Bay region.

The genus *Buprestis* includes a great many medium-sized to large beetles, the larvae of which bore in the wood of broadleaved and coniferous trees. They are found practically throughout the United States and Canada. Some species do considerable damage to trees by mining the wood of the main trunk. Some are of considerable benefit because they mine the wood and cause more rapid disintegration of stumps and other debris left in logging.

Control of the injurious species is difficult. Keeping the forest in as sanitary condition as possible lessens the damage. All wounds on

valuable trees should be protected by shellacking and covering with a good protective paint.

The golden buprestid, *Buprestis aurulenta* L., is a golden-green or blue-green beetle with four ridges on each elytron. Usually the elytra are edged with copper margin, and often the thorax is coppery. The length varies from 12 to 23 mm. The larvae are common miners in the pitchy wood of scars on stumps, trunks, and branches of pine, spruce, and Douglas fir and have been reported from western red cedar. They cause considerable damage to the wood of lightning-struck, fire-scorched, blazed, and otherwise injured standing trees by mining the pitchy scars. They also attack sawn lumber, being one of the very few species of Buprestidae which do not absolutely require bark in which to lay their eggs. The larvae may live for years in the wood, transforming and emerging as a beetle years after the wood has been made into lumber and used in houses, etc. Pupation and transformation to the adult take place in a cell in the wood during the late summer or autumn, and the beetle winters over in the cell and emerges the next spring or summer. The usual life cycle is three years or more. The species occurs throughout the Rocky Mountain and Pacific states and southwestern Canada.

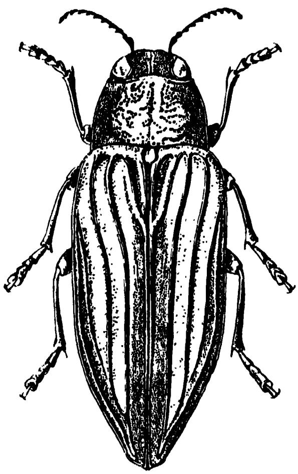
FIG. 59. The golden buprestid, *Buprestis aurulenta* L. × 4.

B. striata Fab. is quite similar to *aurulenta* except that the color is usually brown with faint greenish reflections; the size is slightly smaller. The range is from southeastern Canada to eastern Texas. The hosts are pine and hemlock. *B. sulcicollis* (Lec.) is slightly smaller than the preceding species, dark brown in color, with the elytral ridges convex, and the third short. It occurs in southeastern Canada and northeastern United States in pine. *B. adjecta* (Lec.) is shorter and stouter than *aurulenta,* and the elytra have eight ridges. The color varies from green to coppery, with the under surface usually violet. The range is from British Columbia to California through the Rocky Mountain and Pacific states. The hosts are pine and fir. *B. apricans* (Hbst.) averages slightly larger than *aurulenta;* the color is dark brown, and the elytra are without distinct ridges. The species attacks injured, dying, and dead pines throughout the southern states. Considerable injury is caused to longleaf pine boxed in turpentining. The mining of the heartwood by the larvae weakens the trunk and

often causes the tree to break over, as well as spoiling portions of it for lumber. One per cent of the output is sometimes ruined, and 5 per cent reduced to lower grade. *B. decora* (Fab.) is a narrow green species; the elytra are without ridges, and the tips are bidentate. It lives in dead pine in the Southern states, wintering over as a beetle in a pupal cell in the wood. The life cycle takes several years. *B. salisburyensis* (Hbst.) is a short oval green species, the tips of the elytra having a single tooth on the inner margin. The species occurs from Wisconsin to Massachusetts and south to Georgia.

B. maculativentris Say is a dark-brown to greenish oval beetle from 14 to 20 mm. in length. The face is partly yellow, and there is a row of yellow or orange patches along each side of the abdomen. The species ranges through southeastern Canada and the northern states to the eastern slope of the Rocky Mountains. *B. rusticorum* (Kirby) is broader, darker, and more oblong than *maculativentris*. The elytra are strongly furrowed, and there is a row of yellow or red spots along each side of the abdomen. These spots are often reduced to a single pair on the last segment. The species ranges through the Rocky Mountain and Pacific states in Douglas fir and white fir. It does very little damage and is of some benefit because of its habit of mining dead wood. *B. subornata* (Lec.) is similar to *rusticorum* except that the color is dull green or bronze with a violet tinge. The range is the Rocky Mountain and Pacific states; and the host plant, ponderosa pine. *B. maculipennis* Gory is rather small (10 to 15 mm. long), blackish with a brassy tinge, and has the elytra marked with scattered yellow spots or patches. The range is from Maine to Florida and Missouri; and the hosts, pine and hemlock. *B. lineata* (Fab.) is a medium-sized dark beetle 12 to 17 mm. long, usually with two more or less connected brick-red to yellow longitudinal markings on each elytron. It ranges through the Atlantic states from Canada to Texas. *B. nuttalli* (Kirby), a black-bronze, glossy beetle, 15 to 17 mm. long, has each elytron usually marked with three equidistant irregular yellow spots arranged in a longitudinal row. The range is north from Wyoming to eastern and western Canada and Alaska. The host plant is pine. *B. alternans* (Lec.) is slightly longer than *nuttalli*. The colors are about the same, but the yellow elytral patches are more broken up by the elytral ridges, and the elytral intervals are alternately more convex. The species lives in pine in the Rocky Mountain states. *B. consularis* Gory is similar to *alternans*, but the elytral intervals are not so strongly convex, and the yellowish patches are divided by the elytral grooves. The range is northeastern; and the host plant, pine. *B. laeviventris* (Lec.) is 14 to 20 mm. long, greenish to blackish bronze, with each elytron marked by large yellow

patches more or less connected into a longitudinal stripe. It occurs in the Pacific states, where it is the commonest buprestid around pine. It is of considerable benefit because it mines in stumps, snags, etc., and assists in the rapid disintegration of dead trees.

B. langi (Mann.) is from 13 to 21 mm. in length. The general color is a golden green, sometimes with bluish or purplish tints. Each elytron of the female may be entirely green or marked with one or two bars of waxy white or yellow. Each elytron of the male is marked by three bars of white or yellow. The range is from Alaska to Mexico through the Rocky Mountain and Pacific states. This beetle is reared only from the wood of Douglas fir, although the adults frequent the leaves of the willow, poplar, and alder. *B. fasciata* Fab. is similar to *langi* but slightly smaller and usually darker, with the elytral intervals between striae broad. Larvae and host plants unknown. The adults have been found on pine logs and on maple and poplar foliage. The range is throughout the Eastern states and Canada from Minnesota to Quebec and south to the West Indies. *B. connexa* Horn is 13 to 15 mm. long, with coppery thorax and brilliant green elytra edged with coppery side margins. It has been reared from ponderosa pine and Jeffrey pine in Oregon and California.

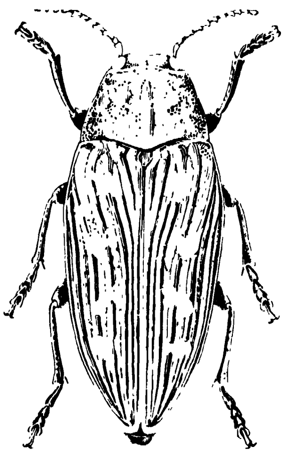
FIG. 60. *Buprestis laeviventris* (Lec.). × 2.5.

B. confluenta Say is elongate oval, 12 to 17 mm. long. The ground color is emerald green to blue-green, and the elytra are covered with numerous yellow spots. The males are marked beneath with yellow patches. The species has been reared from aspen and cottonwood. The distribution is the Pacific, Rocky Mountain, and northern Mississippi Valley states to Canada. *B. rufipes* (Oliv.) is rather slender, 12 to 28 mm. long, dark green, with the elytra marked with a long yellow basal patch and two cross bars of yellow. The food plants are hickory, beech, chestnut, oak, elm, tulip, poplar, and sour gum. The range is from Kansas to New Jersey and south to Florida and Texas. *B. fremontiae* Burke is broad oval, 16 to 20 mm. long, thorax brownish bronze, elytra reddish yellow marked by a single purple spot or patch near the middle of the outer margin. The food plant is fremontia, slippery elm, or leatherwood, *Fremontia californica*, and the range eastern and southern California. *B. viridisuturalis* N. & W. is elongate oval, 11 to 22 mm. long, thorax emerald green, elytra

reddish yellow with a green sutural stripe and one or two green cross bars behind the middle, often tipped with orange. The food plants are cottonwood, poplar, and alder, and the range is from Washington to California. *B. gibbsi* (Lec.) is from 15 to 20 mm. long, general color dark green. Each elytron is marked by three rather large yellow patches. The last two are smaller than the first and usually edged with orange. The food plants are black and Garry oak, and the range is Washington, Oregon, and California.

The genus *Melanophila* Esch. includes small to medium-sized beetles the larvae of which bore in the inner bark and outer wood of coniferous and, rarely, broadleaved trees. The life cycle is usually one year. In some cases, however, part of the brood will remain in the larva stage for several years. They are found throughout the timber areas of Canada and the United States.

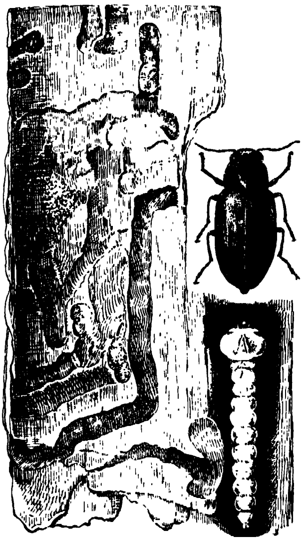

FIG. 61.—*Melanophila drummondi* (Kby.), adult, × 5.3, larva × 3.3, and larval mines on inner bark. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Edmonston.*)

Some species cause considerable damage to the forests of the Pacific states by attacking living trees and mining the cambium. Many trees are killed, and others which recover have the wood seriously damaged by the gum-spot defects which develop in the wood that has been injured by the mines.

Melanophila notata (Cast.) is blackish bronze with elytra marked with yellow. The yellow design may vary from a broad band to small spots or may be entirely missing. The range is from Indiana to New Jersey and south to Florida. The host plant is pine.

M. consputa Lec. resembles *notata,* but the tips of the elytra are rounded, and the first segment of the posterior tarsi is not longer than the next two. The larvae mine the inner bark and outer wood of injured, dying, and dead pine and incense cedar.

The beetles are common in late summer around burned areas. Apparently they prefer to lay their eggs on scorched trees. Smoke appears to attract them, and often they are common around forest fires, smelters, etc., where they crawl on the workmen and nip them.

M. acuminata (De G.) is similar to *notata,* but the front is more densely punctured, and the color is always black. The host plants

are pine, spruce, fir, and arborvitae. The range is from Pennsylvania to Wisconsin and west and south through the Rocky Mountain and Pacific states. These beetles also like smoke and are common around forest fires and scorched timber.

M. atropurpurea (Say) is similar to *acuminata*, but the color is more shiny, and the tips of the elytra terminate in a true spine. The host plants are Monterey cypress, incense cedar, oak, and mountain mahogany. The reported range is from Kansas west to the Pacific states.

FIG. 62. Larval mines of *Melanophila californica* Van D. in inner bark of Coulter pine. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Photo by Miller.*)

M. drummondi (Kby.) is slightly shorter and broader than the preceding species. The color is dark brownish bronze. The elytra are often marked with three or four small yellow spots; the tips are rounded. The thorax is transversely ridged, and often there are three longitudinal ridges on each elytron. The species attacks and kills many trees and causes defects to form in the wood of others which it attacks but fails to kill. The host plants are larch, spruce, hemlock, Douglas fir, and true fir. The range is from Brunswick to Quebec, Hudson Bay, Alaska, and south through the Rocky Mountain and Pacific states.

M. drummondi abies C. & K. is similar to *drummondi* except in color, which is bright green. The host plant is balsam fir; and the range, from New Brunswick to New Hampshire and Quebec.

M. fulvoguttata Harris is similar to *drummondi* except that the thorax and the elytra are not ridged. The host plants are hemlock, spruce, and larch. The species is a destructive enemy of the eastern hemlock where the trees are undergoing adverse conditions such as drought, drainage, or those that follow lumbering. The range is from Maine to North Carolina and west to Michigan.

M. californica Van D. is similar to *fulvoguttata* but is narrower and more convex, with more acute angles to the thorax and with a subserrate ridge on the last ventral segment near the side margin. The host is pine; and the range, California and southern Oregon.

M. pini-edulis Burke is similar to *fulvoguttata* and *californica* except that the markings on the elytra are considerably larger, and the submarginal ridge on the last ventral segment continues around the apex. The host plant is the piñon pine; and the range, Colorado, Utah, and Arizona. This species assists bark borers and bark beetles to kill weakened trees.

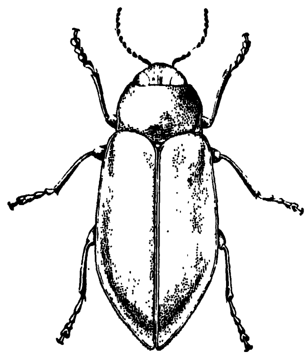

FIG. 63.—*Melanophila gentilis* Lec. × 3.5.

M. gentilis Lec. is 8 to 14 mm. long and dark green or bluish green in color. The thorax and elytra are evenly punctured, and there are no ridges or spots. The host plants are pines, and the range is from South Dakota through the Rocky Mountain and Pacific states. The species is very injurious to second-growth pine in some localities, especially sugar pine, and often kills both small and large trees.

The preceding species work in a similar manner and have larvae that are difficult to differentiate. The following two species work in small suppressed trees, in the lower suppressed branches of large trees, or in the tops of dying and drying-up trees. The rugose areas on the plates of the prothorax of the larvae are much narrower than those on the plates of the preceding species.

M. intrusa Horn is a dark-bronze species 6.5 to 10 mm. long, with the thorax usually brighter and more coppery than the elytra, which are covered more or less with some short, light hairs. The range is from Colorado to California and Arizona. The host plants are various pines.

M. aeneola Mels. is similar to *intrusa* but smaller. The range is from the New England states to Michigan and south to Georgia. The host is pine.

The genus *Agrilus* Steph. contains a large number of species of small, slender, dark greenish, bluish, or coppery-bronze beetles,

usually of a single color but sometimes spotted and sometimes with the head and thorax of a different color from the elytra. The larvae are long and slender, white or yellowish white, and the last segment bears a pair of distinct dark-toothed sclerotized projections. Each plate of the first segment is marked by a single median bisecting line.

The larvae are borers in the inner bark and wood of the twigs, branches, trunks, and roots of a great variety of broadleaved trees and shrubs. Some species mine the growing wood and cause enlarged growths or galls to form.

Pupation and transformation to the adult take place in a cell in the bark or wood during the spring, and the adult emerges soon afterward through a different opening from the one through which the larva excavated the cell.

The life cycle is one year for many species and two years for many others.

Numerous species are of considerable economic importance because they kill twigs, branches, or often the entire tree.

Injurious species may be controlled by cutting out and burning the infested twigs and branches or by cutting and treating infested trees by burning or removing them to places where the emerging insects cannot escape to lay their eggs on other trees.

Repellent washes on the bark or poisoned sprays on the foliage may afford some protection to ornamental trees.

According to their work the numerous species of the genus may be divided into five groups: those that girdle and kill twigs and small branches on living plants, those that mine the shoots of living plants, those that girdle and kill large branches and the trunks of living plants, those that mine dying or dead twigs on living trees, and those that mine in the bark and wood of dying trees.

Pacific oak twig girdler, *A. angelicus* Horn.—This is a typical representative of the group that girdle and kill twigs on living trees. It attacks and kills many twigs on various species of oaks in central and southern California, the twigs of the California live oak being preferred. The killing of the twigs gives the tree a very ragged appearance and destroys to a considerable extent its value as an ornament.

The life cycle is two years. The slender, brownish-bronze beetles, 5 to 7 mm. long, with coppery or slightly golden thorax, emerge from the twigs during May and June. The males have dark-green faces, and the females brownish-bronze ones. They crawl and fly over the foliage, feeding on the leaves and mating. Soon after mating, the females lay dull, white, flattened, oval, scalelike eggs, 1¼ mm. long, singly on the smooth bark of a living twig near the end of the

last year's growth, usually near the base of a small lateral twig or leaf scar. The egg darkens with development and in a few days becomes shiny black. It is covered with a varnish-like substance which catches the dust, etc., so that in a week it looks like the brownish or blackish-gray bark of the twig.

In from two to three weeks each fertile egg hatches by the young larva's boring through the bottom of the shell down into the tissues of the twig. It mines down the twig, boring through the inner bark and wood, usually spiraling the twig and killing the part mined. During the first year the mine goes down the twig only a few inches, and just a few leaves turn brown. The second year the spiral mining continues for a foot or more down the branch, all the twigs and smaller branches terminal to the end of the mine are killed, and a considerable number of leaves turn brown. During the second winter the larva spends considerable time outstretched in the mine in the wood of the branch. The second spring it does some more spiral mining through the cambium and then bores back up the branch for an inch or so, goes into the wood, and excavates an oblong, oval pupal cell, which terminates close to the outer surface of the bark. The full-grown borer is slender, whitish, and about 18 mm. long. The mouth parts and projections on the thirteenth segment are dark brown or black.

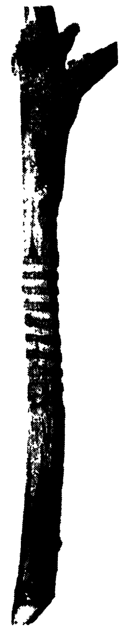

FIG. 64. Work of Pacific oak twig girdler, *Agrilus angelicus* Horn., on live oak.

As soon as the pupal cell is formed the borer shortens up to about half its former length and soon pupates into a delicate white object with the head, body, wings, and legs faintly indicated. The eyes soon begin to darken, and in about two weeks all the head, thorax, and underside of the body have changed to a brownish bronze. The wings and elytra, which are folded on the breast, and the dorsal surface of the abdomen remain white. Transformation of the pupa to the beetle now takes place, and the wings and elytra move over the back. Soon the back and elytra take on the normal bronze color of maturity, and in a few days the beetle gnaws its way through the thin layer of bark and crawls out on the branch and to the foliage. This is about 23 months after the egg was laid.

Although the twig girdler does considerable damage to oaks in California, it has troubles, too. Nine species of hymenopterous parasites have been reared from its larval mines and pupal cells. In one locality 50 per cent of the girdlers were parasitized by a single species, *Doryctes maculipennis* Rohwer.

The best method of control is to prune out the infested branches about Apr. 1 and place them in a box or barrel covered with a 16-mesh wire screen. This keeps the beetles in, and they soon die, but allows the escape of the parasites, which are able to fly to the trees and attack any girdlers missed in the pruning.

The oak twig girdler, *A. arcuatus* (Say), is similar to *A. angelicus.* The beetle has the head and pronotum uniformly brownish cupreous and elytra black. The range is Massachusetts to Montana and south to Mississippi. The oak, beech, and chestnut are attacked.

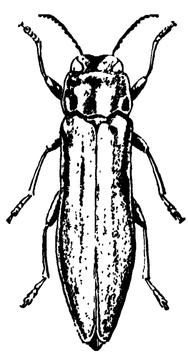

FIG. 65.—The bronze birch borer, *Agrilus anxius* Gory. × 3.5.

The hickory spiral borer, *A. torquatus* Lec., attacks hickory and pecan and ranges from Massachusetts to Illinois and south to Mississippi.

The bronze birch borer, *A. anxius* Gory, is a typical representative of the group that kills trees. The beetle is olive bronze in color and 5.5 to 13 mm. long. It occurs throughout southern Canada and most of the United States except the South. Practically all species of birches, poplars, and cottonwoods are attacked and killed. It is sometimes a serious enemy of ornamental birches in eastern Canada and eastern United States. One year a few branches of the top may be attacked, and then the rest of the top and the main trunk in the next year or two. The life cycle is one year. The beetles emerge during spring or early summer, feed on the foliage, mate, and lay their eggs singly, sometimes close together, in the crevices or rough places of the bark. In a few weeks the eggs hatch, and the young larva bores through the bottom of the shell down into the inner bark. It gnaws a mine as much as 5 ft. long, winding and twisting through the inner bark and deep down into the wood and out again. By fall the larva has become full-grown and excavates a pupal cell in the wood close to the bark. In this it rests until spring, when it pupates, transforms to a beetle, and emerges in a few weeks.

Control of the bronze birch borer in ornamental trees consists of cutting out and burning all dying and dead infested trees or parts of trees. Usually, although only a few branches of a tree are attacked the first year, the attack will continue and kill the tree unless the infested parts are cut out and destroyed. In the forest, control consists of clean cutting and growing a dense stand.

A. betulae Fisher is a little green species 7.5 mm. long which works like *anxius.* It attacks river birch in Maryland and Virginia. *A. populi* Fisher is a bronzy or coppery-green species 7 to 10 mm. long which attacks poplar and cottonwood from British Columbia and

Montana to California. *A. fulminans* Fisher attacks willow in southern California, Arizona, Nevada, and Utah. *A. granulatus* (Say) attacks poplar and cottonwood from southeastern Canada to Montana and south to Colorado and North Carolina. *A. quadriguttatus* Gory is a large 10-mm. olive-green to dark-brown species, with three indistinct pubescent spots on each elytron. It attacks willow from Pennsylvania to Colorado.

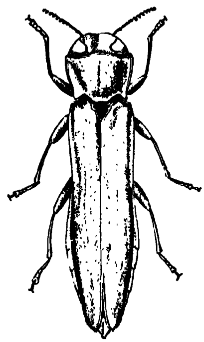

FIG. 66.—The two-lined chestnut borer, *Agrilus bilineatus* (Web.). × 4.

A. quadriimpressus Zieg. is olivaceous to black, 7 to 10 mm. long. It attacks oak from Massachusetts to Michigan and south to Oklahoma and Virginia. *A. quercicola* Fisher is 5 to 9 mm. long, with pronotum green and elytra black. It attacks oak from Colorado to Utah and south to New Mexico and Arizona.

The two-lined chestnut borer, *A. bilineatus* (Web.), attacks and kills many oaks and chestnuts in the eastern states. The beetle is 4 to 9.5 mm. long; the pronotum and elytra are black, with a narrow strip of rather dense yellowish or whitish pubescence. The species works much the same as *anxius*, except that the larvae work more in the trunk, and pupation often takes place in the thick bark. The range is from eastern Canada to the Rocky Mountains and south to Texas. The variety *carpini* Knull attacks beech, blue beech, and ironwood in Connecticut and Pennsylvania. *A. juglandis* Knull is 5.5 mm. long, with brownish pronotum and blackish elytra. It occurs from Connecticut to Michigan and south to Virginia. The larvae live in the outer bark of living butternut, injuring the tree so that it becomes attractive to other insects.

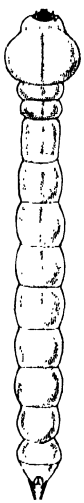

FIG. 67.—Larva of the two-lined chestnut borer, *Agrilus bilineatus* (Web.). × 4.

A. politus (Say) is a small, slender species about 5.6 mm. long. The color varies from golden green to bluish green and through all shades of cupreous to plumbeous. The range is through southern Canada and practically all sections of the United States. The larvae live in numerous species of willow and dwarf maple and striped maple. Living willows are attacked and killed or partially killed by the mining of the larvae. Throughout most of the range the life cycle is one year; in the northern part it may be two years. The eggs are laid on the outer bark in flattened circular masses of from one to twelve eggs, each mass covered with a varnish-like secretion. Pupa-

tion usually takes place in a cell in the outer wood. The variety *burkei* Fisher resembles *politus* except that the color is deep blue. It occurs from British Columbia to California and east to Wyoming. It attacks living alder and often kills many trees or parts of trees in California. Sometimes the tree overcomes the attack, and the old scars of the wood are covered over by new wood.

Although most of the species that attack and kill trees will attack and live in recently felled and dying trees, there are a number of species that, so far as we know, attack only recently felled or dying trees or the dying branches of living trees. Little is known of their life history, but the life cycle appears to be one year.

FIG. 68.—Cross section of a cedar pole showing tunnels made by the western cedar borer, *Trachykele blondeli* Mars.

A. difficilis Gory occurs from Michigan to Iowa and south to Louisiana and Texas in prickly ash, *Xanthoxylum*, and honey locust, *Gleditsia; A. fuscipennis* Gory, from N. Carolina to Ohio and south to Texas in box elder and maple; *A. defectus* Lec., from Massachusetts to Iowa and Texas in oak; *A. otiosus* Say, from Massachusetts to Iowa and south to Mississippi in hickory; *A. transimpressus* Fall, from New Jersey to Indiana and south to North Carolina and Arkansas in black walnut; *A. frosti* Knull, from Massachusetts to Manitoba south to North Carolina in oak; *A. fallax* Say, from southeastern Canada to Iowa and south to New Mexico and Texas in honey locust, *Gleditsia*, and hackberry; *A. obsoletoguttatus* Gory, from Maine to Wisconsin and south to Texas and Louisiana in beech, blue beech, birch, ironwood, *Ostrya*, oak and hickory; *A. impexus* Horn, from Minnesota to Wyoming and south to Mississippi, Texas, and Arizona in paloverde and possibly honey locust and black locust, *Robinia;* and *A. egenus* Gory, from eastern Canada to Wisconsin and south to Texas in black locust.

The medium-sized greenish or dark bronzed beetles belonging to the genus *Trachykele* Mars. have a thorax rather roughly sculptured and with a large anterior median depression. The larvae are wood borers in the sapwood and heartwood of the trunks, tops, and branches of various living conifers

Pupation and transformation to the adult take place in a cell in the wood during the summer or fall. The beetles emerge in the spring. The life cycle takes several years to complete.

The genus is southern and western, ranging from Virginia to Texas and from British Columbia to New Mexico.

Considerable damage to trees of economic importance is caused by the mining of the larvae of some of the species.

FIG. 69.—Larval mines made by the western cedar borer, *Trachykele blondeli* Mars., in heartwood of red cedar pole. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Photo by Miller.*)

The western cedar borer or **powderworm,** *Trachykele blondeli* Mars., is the species of greatest economic importance. This species, which occurs from British Columbia to California and also in New Mexico, attacks healthy, living western red cedar and cypress trees and often causes serious injury to the wood of the main trunk by riddling it with long, winding, flattened, oval mines. The mines in the wood ruin it for use as staves, shingles, boat strips, or shiplap, where tightness is required, and cause serious defects in furniture and finishing stock, which should be free from all blemishes. Wormy timber may be used for poles, posts, planking, sills, or other material, where clearness and tightness are of no particular importance.

T. blondeli is a rather brilliant bronze-green beetle, usually with two rows of velvety black spots on the wing covers, which are oftened margined with coppery bands. The sides of the thorax are angulate. The size varies from 15 to 20 mm. in length and 4.5 to 7 mm. in breadth. The egg is whitish, oblong, rounded at one end, bluntly pointed at the other, with the surface reticulated and about 2.5 mm. in length and 1 mm. in breadth. The full-grown larva is a white grub about 38 mm. in length, with the first segment behind the head about 8 mm. in breadth. The thorax is broad and flattened,

the abdomen long and almost cylindrical. The dorsal plate is marked by two paramedian grooves forming an inverted V, with an oval, shining depression at the anterior end. The ventral plate is marked by a broad, median, shining groove occupying the posterior two-thirds of the plate, with a broad, oval, shining depression at its anterior end. The pupa is about the size of the adult, oblong oval, white, and with a bluntly pointed head.

The species overwinters as an immature larva in a mine or as a young beetle in a pupal cell in the wood. The beetles emerge during April, May, or June, fly to the foliage, feed on it, mate, and the female lays her eggs before the end of July.

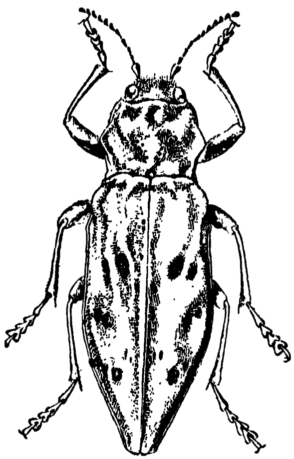

FIG. 70.—*Trachykele opulenta* Fall. × 4.

The eggs are laid under the bark scales of branches on living trees. They hatch in from two to three weeks, and the larva starts boring through the bark and down into the wood. It follows this down the branch into the trunk and up and down through the wood of the trunk for many feet until it becomes full grown, when it bores to within an inch or half an inch of the surface and excavates an oval cell, in which it pupates and transforms to the adult.

Many larvae bore back into the branches to form their pupal cells. Most of the full-grown larvae pupate in July and August and transform to beetles about three weeks later. The beetles remain in the pupal cells over the winter and until late in the spring or summer before emerging. The complete life cycle probably takes at least three years and often much longer.

Since *T. blondeli* attacks and mines the wood of living trees only, control is rather difficult. Clearing up and destroying the tops and larger slash after logging should destroy many beetles. Much loss can be prevented by using the wormy logs for poles, posts, planking, sills, or other material where tightness is of no particular importance and where wormy timber is practically as good as sound material. Once a tree is cut, it is not liable to further attack, and any infesting larvae usually die before causing much further damage.

The western juniper borer, *T. blondeli juniperi* Burke, is a variety of the cedar pole borer. It is smaller and of a more delicate and brilliant green color. It attacks the wood of western juniper in the Sierras of California and causes considerable damage in some localities.

T. opulenta Fall is about the same size as *T. blondeli*. The color is not such a shining green, and the sides of the thorax are more rounded. It attacks and mines the wood of the incense cedar and the California big tree. The life history is practically the same as that of *T. blondeli*.

T. hartmani Burke is a rough, dark-bronze beetle with black velvety patches on the wing covers and an angulate thorax. It is slightly larger and heavier than *T. blondeli*. It attacks and mines the wood of the Sargent cypress in central California but is not common.

T. nimbosa Fall is slightly smaller than *T. blondeli* (12 to 17 mm. in length, 4 to 5.5 mm. in breadth), brownish bronze in color, and with the thorax slightly angulate. It attacks red fir, white fir, and mountain hemlock in the mountains of California, Oregon, Washington, and British Columbia. It has been reported from Colorado.

T. lecontei (Gory) is the smallest species of the genus, varying from 9 to 13.5 mm. in length and from 3.2 to 4.5 mm. in breadth. It is light brownish bronze in color, with the wing covers marked by black velvety patches and the sides of the thorax almost parallel. The life history is similar to that of the other species. The wood of the bald cypress is attacked, and some damage is caused. The species has been found from Virginia to Louisiana.

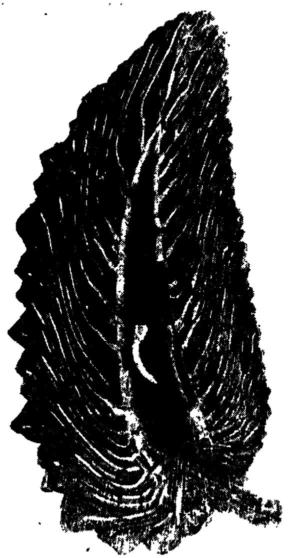

FIG. 71.—The larva of *Chrysophana placida* (Lec.) attacking cone of knobcone pine. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Photo by Patterson.*)

The genus *Chrysophana* Lec. contains only a single species, *C. placida* Lec. These beetles are oval, flattened, and from 7 to 12 mm. in length and 3 to 5 mm. in breadth. Some specimens are entirely green or blue-green in color, some entirely reddish bronze, but most are greenish with a broad reddish-bronze stripe on each elytron. The larva is white, about 20 mm. in length and 4 mm. in breadth when full grown; the first segment is broader than those following, and both the dorsal and ventral plates are marked by a light median groove.

The larva is a wood miner in the main trunk, branches, and cones of various coniferous trees. The larval mine usually starts from a dead spot on the outer surface of the tree and winds back and forth through the solid wood until it ends in the pupal cell near the

surface. The borings are rather fine. The beetle flies about the trees in the forest and often rests on the foliage, where it feeds and mates.

Pupation and the transformation to the adult stage take place in the late summer or fall. The adult overwinters in the pupal cell and emerges in the early spring. Beetles have been found in the field from March to September, and recently adults have been taken from moss on trees during the winter months. Apparently it takes several years to complete the life cycle.

The species is found in practically all the Rocky Mountain and Pacific states.

The wood of various pines, the mountain hemlock, Douglas fir, various true firs, and the giant arborvitae are mined. Usually, however, little damage is done. In a few instances pine window and door casings in buildings have been attacked by successive generations of borers and severely injured. The main stems of the cones of the Coulter pine and the knobcone pine are attacked and mined, but very little damage results to the seed crop.

Efficient forest sanitation should control this species in the forest. Regular repainting of exposed wood surfaces should prevent reinfestation of timber in buildings.

The genus *Acmaeodera* Esch. includes the bald cypress sapwood flathead, *Acmaeodera pulchella* (Hbst.), which often riddles the sapwood of the trunks of dying and dead cypresses in the southern United States. It has been particularly injurious to trees "deadened" for several years in the old method of lumbering to dry out the logs before cutting and floating them in the water.

The adult is a blackish or blue-black beetle 9 to 10 mm. in length, with the posterior angles of the thorax and the elytra marked by large patches or bands of waxy yellow. The larva is milk white in color and about 13 mm. in length.

The adults fly during the early summer and attack the trees. Various-sized larvae can be found in the wood during the entire year.

The best control for this species is the practice of forest sanitation. Deadening trees during October, November, and December should prevent some damage. If logs are left in the woods over the summer season, they should be peeled.

The genus *Chalcophora* Sol. includes large, dark, bronzy, elongate-oval beetles with tarsi more or less depressed, pronotum with a longitudinal median flattened carina and prosternal process longitudinally grooved.

The larvae are wood borers in the trunks and stumps of coniferous trees.

The range is throughout the United States where conifers grow.

None of the species is of great economic importance. Some cause damage by boring the wood of trees of commercial importance. Some are beneficial, since they assist in the more rapid disintegration of the stumps and larger pieces of slash left after logging.

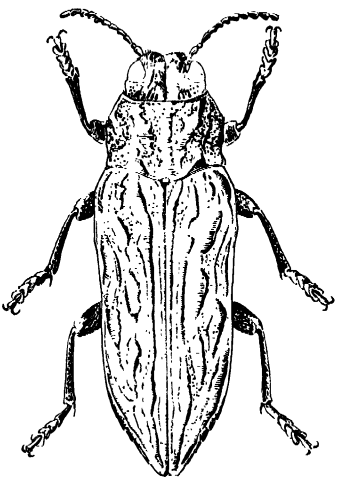

FIG. 72.—*Chalcophora angulicollis* (Lec.). × 2.

Chalcophora angulicollis (Lec.) is the largest buprestid in the United States, being from 22 to 31 mm. in length and 8 to 11 mm. in width. The color is grayish bronze marked with smooth, black, shiny lines and elevated areas. The full-grown larva is 40 to 50 mm. long, yellowish or creamy white in color. The rugose areas of the first segment and the dorsal Y and ventral median line are heavy and distinct.

The beetles fly from April to September. The eggs are laid in crevices of the bark or in the emergence holes of bark beetles or other insects. They resemble small hymenopterous cocoons and are laid in masses. The larvae bore through the cambium to the wood and mine that for several years before pupating and transforming to the beetle in a cell in the wood at the end of the mine. Pupation and transformation to the adult take place in the summer or fall, and the young beetle rests in the pupal cell until the next spring or summer before emerging.

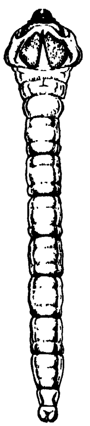

FIG. 73.—Larva of *Chalcophora angulicollis* (Lec.). × 1.

Dying and dead pine, fir, and Douglas fir are attacked, especially stumps, and the wood riddled with large, flat, winding mines.

Keeping the forest clear of fallen trees and stumps should prevent this species from becoming destructive.

The species ranges throughout the Rocky Mountain and Pacific states.

C. virginiensis (Drury) resembles *angulicollis* so closely as to suggest that the two may be one species. It attacks injured, dying, and dead pine throughout the eastern and southern states. Dr. Hopkins reported it as causing serious injury to mature white pine in West Virginia. The larvae enter wounds and scars on living trees and mine

the wood of the trunk, riddling it for many feet. *C. georgiana* (Lec.) is slightly smaller than *angulicollis* and more golden bronze in color. It attacks pines in the southern states. *C. liberta* (Germ.) is smaller and coppery in color. It is found on pines in the northeastern states. *C. fortis* Lec. is a large, coppery species found in the northeastern states.

The genus *Dicerca* Esch. includes medium-sized, dark-brown or grayish-brown, oblong, oval beetles which are found throughout the United States and Canada. Many of the species attack deciduous trees.

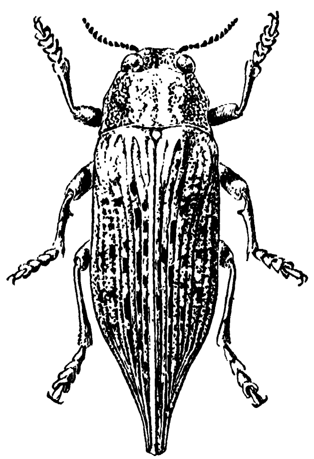

FIG. 74. *Dicerca tenebrosa* (Kby.). × 2.5.

D. americana (Hbst.) is 14 to 22 mm. long, dark bronze, front with only a slight trace of carina, elytra bidentate; lives in dead wood of pine and bald cypress in eastern and southern states; mines cause some damage to the wood of cypress girdled in lumbering operations. *D. scobina* Chev. is slightly smaller than *americana*, front carinate, concave; male with mesothoracic tibiae dentate, tips of elytra bidentate; lives in dead wood of sour gum in the East and South. *D. crassicollis* Lec. is 14 to 19 mm. long, dark bronze, sides of thorax considerably dilated, elytra with dark, smooth, elevated spaces, tips truncate; female with last ventral segment having three teeth; male with intermediate tibiae dentate; mines wood of dead pine in Pacific states. *D. tenebrosa* (Kby.) is similar to *crassicollis* but with sides of thorax less dilated; mines wood of dead pine, Douglas fir, and true fir in Rocky Mountain and eastern states. *D. lugubris* Lec. is similar to *tenebrosa*, coppery, with obvious rows of large punctures and few smooth, elevated areas; northern states and eastern Canada. *D. sexualis* Crotch. is similar to *tenebrosa* but brownish bronze, elevated spaces more conspicuous, intermediate tibiae of male without teeth, apex of abdomen of female rounded; occurs in the Northwest on Douglas fir, true fir, and pine. *D. tuberculata* C. & G. is slenderer than *sexualis*, elytra irregularly tuberculate; attacks living hemlock in the Eastern states, mining dry wood around injuries. *D. horni* Crotch is dark grayish bronze, 13 to 25 mm. long, rather broad apex of elytra slightly prolonged, sutural angle pointed; occurs in the Pacific states in a great variety of broadleaved trees and shrubs; mines wood of dead spots on living trees as well as the wood of dying and dead trees. *D. tenebrica* (Kby.) is a northern species working in cottonwood and aspen.

The genus *Anthaxia* Esch., includes a few small beetles the larvae of which attack the inner bark and outer wood of the trunks and branches of both coniferous and broadleaved trees and shrubs. Usually very little damage is done to plants of economic importance. Sometimes, however, numerous small trees and shrubs are killed. *Anthaxia pseudotsugae* Cham. is greenish black in color and attacks Douglas fir. Most of the other species occur on deciduous trees or shrubs.

The members of the genus *Brachys* are small, oval beetles whose larvae are miners in the leaves of broadleaved trees.

Little is known of the life history. The flattened oval eggs are laid on the upper surface of the leaves during early summer. The larva enters the leaf tissue by mining through the bottom of the eggshell and forms a large blotch mine. By fall it has become full-grown, bores through the lower surface of the leaf, and drops to the ground, where it pupates. Whether it overwinters as a pupa or transforms to a beetle and overwinters is not known. The beetles appear in the late spring and feed on the upper surface of the leaves.

They range from southeastern Canada west to Manitoba and south to Florida and Arizona.

No serious damage to trees of economic importance has been reported.

The genus *Poecilonota* Esch. contains a few species which are very similar to *Dicerca* in appearance but can be distinguished by the scutella's being much broader than long. There are some ten indigenous species, which so far as known breed in various species of *Salix* and poplars.

P. cyanipes (Say) is widely distributed from the Mississippi River to the Rocky Mountains, breeding in various poplars.

P. californica Chamb. is a similar species found in the Pacific Coast and Rocky Mountain states in poplars.

P. montanus Chamb. occurs in *Populus trichocarpa* from Oregon to Montana.

P. salicis Chamb. breeds in willow in southern California, and *P. fraseri* Chamb. is found in willow from British Columbia to the Tahoe region of California.

Species of the genus *Polycesta* Sol. are heavy-bodied, coarsely punctate, and black in color. The larvae mine broadleaf trees, principally oaks. Of the six known species *P. californica* Lec. is the most abundant. The larvae mine the various species of oak and madrone, *Arbutus menziesii*, in California and southern Oregon.

Polycesta elata Lec. and *P. arizonica* Sch. mine various oaks in the mountains of Arizona, while *P. cyaneous* Chamb. is an oak-boring species found in central California.

LONGHORNED BEETLES OR ROUNDHEADED BORERS

The family Cerambycidae is one of the largest, most characteristic, and important of wood-boring beetles. It is characterized by having all tarsi five-segmented, but the fourth segment is much reduced in size and closely joined to the fifth, except in some aberrant genera where it is more evident and independent, though small. The members of the family generally have long, more or less filiform antennae, usually arising from prominent tubercles on the front of the head, well-developed tibial spurs, and many have distinctive color patterns produced by the pile alone. The larvae are elongate, cylindrical or slightly flattened, creamy-white creatures with well-developed heads, sometimes with true thoracic legs, though generally without. The body is deeply creased where the segments join and is provided with large, flattened sucking disks on the upper, lower, and lateral surfaces. The body may taper somewhat posteriorly, but the anterior segments are never suddenly or conspicuously larger than the following ones. Most species live in the dead wood of trees and shrubs, but a limited number dwell in annuals or in the growing plant. Their function in nature is dominantly that of scavengers, but because they attack the timber as soon as it is killed or sometimes when it is only weakened they soon render it unfit for the uses of man and thus are accounted destructive. Only a small number attack and kill the slightly weakened or healthy trees, and an equally small number bark or girdle the twigs.

The methods whereby their destructiveness may be overcome or reduced are in general such as are best accomplished by forest sanitation. Forest growth when kept in a healthy condition is less liable to attack from Cerambycidae than when allowed to become weakened. Old wounds, particularly base wounds and dead stubs, make it possible for the larvae to gain access to the heartwood. Fires, defoliation, drought, the raising or falling of the water table, and old age so weaken the trees that they invite attacks. Trees when felled for lumber purposes should be removed from the forest and lumbered as soon as possible or cut and removed during the season of the year when the adult egg-laying insects are not active as in the late fall or winter. Early barking of logs will also assist in preventing injury, as the young larvae of most species require the soft cambium. The forest slash should also be destroyed as soon after logging operations as possible, for this not only serves as a trap but enables large broods to be produced in the neighborhood which may later become destructive. Similar care should be taken with new plantations. Many trees like the locust need to have the trunk well-shaded when young. Old

stumps, slash, and forest litter if allowed to remain in the neighborhood may produce broods which will later prove quite harmful to the young growth.

The family Cerambycidae is divisible into three subfamilies, the Prioninae, the Cerambycinae, and the Lamiinae. They may be separated according to the following key, as given by LeConte and Horn (1883):

1. Prothorax margined, labrum connate.......... Prioninae
   Prothorax not margined, labrum free.......... 2
2. Front tibiae not grooved.......... Cerambycinae
   Front tibiae obliquely grooved on the inner side.......... Lamiinae

SUBFAMILY PRIONINAE

The members of this subfamily are generally of large size, 25 to 75 mm. in length, the more northern species of brown or piceous color, nocturnal, often attracted to lights but when found in the forests generally associated with their food trees. It is a group primarily of the tropics, South America and Africa having many genera and species. In the Northern Hemisphere there are but few. The principal genera in our territory may be best defined by the agency of a key as the one given below:

1. Fourth tarsal segment distinct though small.......... *Parandra*
   Fourth tarsal segment indistinct and connate with terminal.......... 2
2. Prothorax pluridentate laterally.......... 3
   Prothorax tridentate or parcidentate laterally.......... 5
3. Third antennal segment very long.......... *Ergates*
   Third antennal segment of moderate length.......... 4
4. Mandibles vertical.......... *Archodontes*
   Mandibles nearly horizontal, prolonged in the male.......... *Stenodontes*
5. Metathoracic epimera parallel.......... 6
   Metathoracic epimera narrowed behind.......... *Tragosoma*
6. Antennae filiform in both sexes.......... *Derobrachus*
   Antennae imbricate in males.......... *Prionus*

The genus *Parandra* Lab. is one of the most generalized or primitive of the Cerambycidae, as shown by the tarsi, the fourth segment being evident and functional though small, and by the species' being widely scattered throughout the warmer parts of the world. The species are all more or less elongate, parallel, shining, and of a reddish color. In this country there are but four species, according to Schaeffer (1910). *Parandra brunnea* (Fab.) is common in various parts of the East and according to Snyder (1910) and Brooks (1915) does considerable damage at times to weakened or injured fruit and forest trees as well as to chestnut telephone and telegraph poles. The more

elongate *P. polita* Say is rather rare in the Southern states, though more common farther south in Mexico and Central America, while *P. punctillata* Sch. is to be found in Arizona and *P. marginicollis* Sch. in southern California. The last breeds in the bases of old willows and sycamores. In the mountains of San Diego county, many an old willow tree has been completely hollowed out, partly as the result of the boring of this beetle.

The spined pine borer, *Ergates spiculatus* Lec., is one of our largest wood-boring beetles. It is widely distributed throughout the Pacific slope where it breeds in the wood of various conifers and is often found about the yellow pines and Douglas fir. The adults are of a reddish-brown color, about 57 mm. in length, the females with prothorax somewhat narrower than the elytra, decidedly punctate and rugose above, and with the lateral margins set with numerous spicules; the males with the prothorax larger, more quadrate, about as broad as the elytra, and with much of the disk smooth as the result of flattened callosities, the antennae also somewhat more robust and longer. The larvae when full-grown are from 50 to 75 mm. in length and over 12 mm. in width. They may be readily separated from our other large cerambycid larvae by having the front quadrituberculate, the mandibles acutely triangular from the sides, rugose, with the inner face fully striated, three indistinct ocelli, antennae thick, short, the last segment cylindrical, and plural disks finely rugose and visible on six abdominal segments though distinct on but three. They live in the main trunks of various species of pine as the ponderosa, sugar, and Monterey, as well as in Douglas fir. Their burrows are large, first rambling through the sapwood, later dipping down into the heart of the tree. The larvae are often found in lumber, sometimes a long time after it is milled.

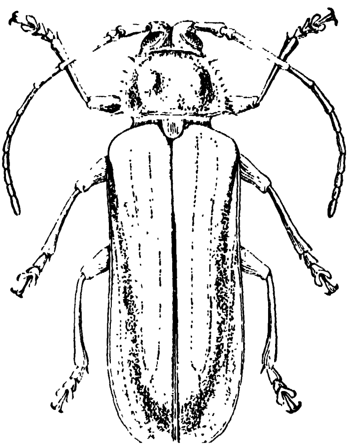

FIG. 75.—The spined pine borer *Ergates spiculatus* Lec. × 1.

The genera *Archodontes* Lmr. and *Stenodontes* Serv. are quite closely related and are limited to our Southern states, extending westward into Arizona. They are more numerous in Mexico and farther south. They are elongate, brown or piceous in color, with large heads. Some species are very large, the males in particular, which also have very large mandibles and a broad, flattened prothorax

ornamented with smooth callosities. The larvae have as distinguishing characters the epistoma with two broadly triangular lobes projecting over the extremity of the clypeus, the front produced in the form of a dull carina, the mandibles short and with the outer face rugose, three indistinct ocelli, plural disks rugose and distinct on first and second segments, faint on the next three. These beetles will burrow in the trunks of trees as observed by Schwarz in Texas where he found a larva in the heart of a large hackberry, *Celtis*, but they also attack the roots of young oaks as noted by Riley (1884) and quoted by Packard (1890) for *Archodontes melanopus* (L.). By continually gnawing at the growing tissues, they cause the trees to divert their sap to the roots, producing in time enormous underground galls, the main growth above ground meanwhile being limited to a brushlike formation. Thus this beetle acts more as a parasite than as a scavenger and exerts a profoundly limiting effect upon oak reproduction in the hummock lands of the South.

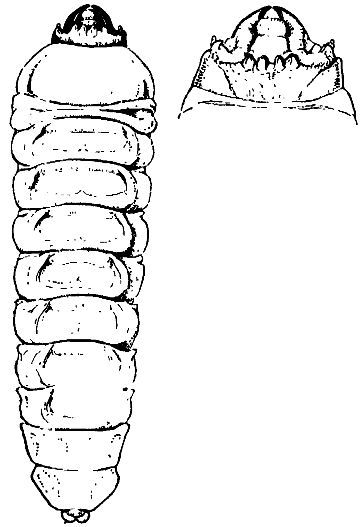

FIG. 76. Larva of the spined pine borer, *Ergates spiculatus* Lec. × 1. At right, details of head and mouth parts. × 2.

The genus *Derobrachus* Serv. contains species that are rather large, elongate, parallel-sided, brown, and more or less smooth. The antennae are quite long and robust, and the prothorax narrower than the elytra and with each side margin armed with three teeth or spines. *Derobrachus brunneus* (Forst.), the common eastern species, is about 30 mm. long, breeds freely in most hardwoods and coniferous trees, and is particularly destructive to structural timbers in contact with the ground. The larger and more spiny *D. brevicollis* (Serv.) and *D. geminatus* Lec. are found, the first, in the southern states; the second, in the Southwest, Lower California, and Mexico. They fly readily to light, and *D. geminatus* Lec. has been noted as feeding on the roots of orchard trees during the larval stage in the country about Ensenada, Lower California.

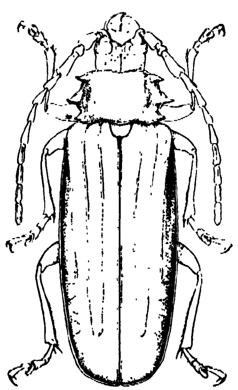

FIG. 77.—*Derobrachus brunneus* (Forst.). × 1.5.

The genus *Prionus* Fab. contains many species, most of which are large and robust and generally of a chestnut-brown or piceous color. About nine or ten valid species occur in North America. They are, in the main, characterized by having mandibles of moderate size, alike in both sexes, coarsely granulated eyes, antennae with from twelve to twenty-seven segments according to the species, much heavier and imbricated in the males, and the prothorax with three teeth on each side in the typical portion of the genus and but one in the subgenus *Homaesthesis*. The larvae simulate those of *Ergates* but may be distinguished by having the front projecting over the epistoma in the form of a simple transverse carina and by being without tubercles, the mandibles nonstriate on the upper inner face, the ocelli absent, the last segment of the antennae a small lobe on a truncated tip, and the pleural disks radially striate or stellate and on six abdominal segments. The larvae, as a rule, lead a subterranean life, feeding on old dead roots, though sometimes attacking living tissues and thus doing at times considerable injury.

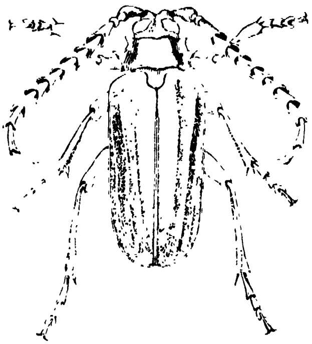

FIG. 78. The California prionus, *Prionus californicus* Mots. × 1.

The California prionus, *Prionus californicus* Mots., the best known western species, is widely distributed throughout the Pacific slope. It is a large species with the antennae twelve-segmented, the soles of the hind tarsi densely pubescent, the elytra at base wider than the prothorax, and the latter with the first two teeth very acute and reflexed. Its preferred food tree is the oak, but it has been found on many other hardwood or broad-leaved trees such as the poplar, apricot, eucalyptus, and grape and even breeds in the stumps and roots of various pines and the Douglas fir as well as in the butts of red-cedar poles. The eggs are laid in crevices near the earth line, the young larvae rapidly working downward. Three to four years are required as is the case with most Prionae before they reach maturity. At times this insect is harmful because of its tendency to work from the dead to living roots. It has also been found to be destructive in cleared logged-over lands, as it apparently breeds in the old dead roots of leftover stumps

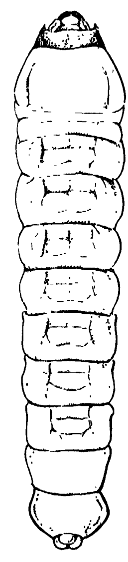

FIG. 79.—Larva of the California prionus, *Prionus californicus* Mots. × 1.

and travels from these to the roots of recently planted fruit or forest trees.

The **broad-necked prionus,** *Prionus laticollis* Drury, a large, dark-brown species, is the best known among the eastern species. It is somewhat rugose and with the prothorax as broad at base as the elytra, otherwise like *californicus*. *P. pocularis* Dalm. simulates the latter even more closely, differing primarily by having the prothoracic teeth prominent and not reflexed. *P. imbricornis* L. has in the male from eighteen to twenty-two antennal segments; and *P. fissicornis* Hald. in the male, from twenty-seven to thirty. The last two species are found in the southern and western states. Other species are so rare that they need not be discussed.

The genus *Tragosoma* Serv. has but one good species in temperate North America, *Tragosoma depsarium harrisi* Lec., a supposed subspecies of the widely distributed Palaearctic *T. depsarium* (L.). It is found throughout the northern portion of our continent from Nova Scotia and Maine to British Columbia, as well as in the Appalachians and the entire Rocky Mountain and Cascade-Sierra Nevada Mountain region. It lives in many types of coniferous trees. On the Pacific Coast it is mainly confined to the north and high altitudes and breeds in the old dead lodgepole pine. It is a reddish-brown beetle, 30 mm. or more in length, the antennae filiform and reaching slightly behind the middle of the body, the prothorax much narrower than the elytra, with a single small spine at the side, and the upper surface clothed with long fulvous hair, the elytra leathery and somewhat sulcate and reticulate. The larvae are very similar to *Ergates* but smaller and with the epistomal teeth flattened and the edges acute.

SUBFAMILY CERAMBYCINAE

This subfamily contains a very large number of genera and species and is perhaps the dominant subfamily in our temperate region, as the Lamiinae is in the tropical. A certain proportion are somber in color and more or less nocturnal in habit, but the majority are rather conspicuously colored and are diurnal. Many of the latter also congregate about flowers. The smaller species as a rule live as larvae in twigs or just beneath the bark, the larger and flatter species also beneath the bark or in the outer sapwood, while the larger and more cylindrical species prefer the deeper sapwood and heartwood. Many species do but little damage, living as they do in useless dead twigs, branches, or stumps; but others may be quite harmful, attacking and killing weakened trees, working their way through old wounds or stubs to the heart of a tree and gradually hollowing it out, or attacking newly felled trees and destroying their value for lumber purposes.

Forty-two tribes of Cerambycidae are represented in our fauna, but about two-thirds of these are either very small or contain genera and species of such little economic importance to the forester and lumberman that they will not be discussed. The others contain either conspicuous or common species or those of considerable economic importance. These will be dealt with serially.

The tribe Spondylini contains but two American genera each with one valid species, *Spondylis upiformis* Mann. and *Scaphinus muticus* (Fab.) The character that most definitely separates the members of this tribe from all others within the subfamily is the presence of the small yet more or less functional fourth tarsal segment. From *Parandra* of the previous subfamily, which also has this character, it can be separated readily by the nonmargined prothorax and free labrum. The beetles are elongate, more or less cylindrical and robust, with large heads, often rather large and curved mandibles, short and moniliform antennae, and robust legs. *Spondylis upiformis* Mann. is a robust, dull-black beetle, 8 to 18 mm. in length, with the second antennal segment much shorter than the third and following segments, with the hind coxae oval and not prominent, and the tibiae with the outer angle but moderately prolonged and dilated. It is found commonly throughout the coniferous forests from Alaska to the Great Lakes and also ranges into the northern Rocky Mountains and throughout the Pacific Coast. *Scaphinus muticus* (Fab.) is a brownish-red beetle, somewhat smaller than the normal *Spondylus*, with the second antennal segment about equal in length to the third, the following segments equal and transverse, the hind coxae prominent, and the tibiae with the outer angle greatly prolonged and dilated. It is restricted to the pine forests of the Southern states.

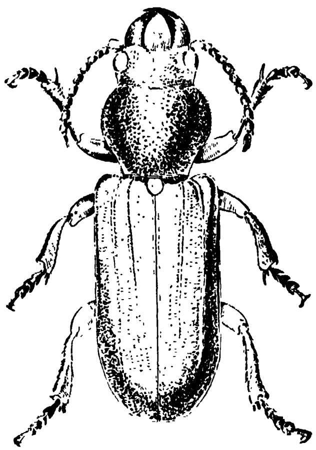

FIG. 80.—*Spondylis upiformis* Mann. × 4.

The members of the tribe Asemini are somewhat elongated and flattened beetles, brownish or piceous in color, and to a great extent nocturnal. The adults are generally found during the day concealed in the crevices of the bark or flattened out beneath the loose bark. They are all restricted to coniferous trees and are sometimes spoken of as "pine stump borers," though they do not confine their work to the stumps. The typical genus *Asemum* Esch. has antennae that are finely pubescent and eyes of moderate size, transverse, finely granular,

and hairy. The species are from 12 to 18 mm. in length. *Asemum atrum* Esch. is a very common species in the Northwestern and Western part of our country. During hot weather, the beetles are common about rural habitations and may often be seen clinging to poles with their heads down and afterbody tilted in the air. They breed freely in lodgepole pine as well as many other types of coniferous trees. In the more eastern part of the country the related *A. moestum* Hald.

FIG. 81.—The black spruce borer. *Asemum atrum* Esch. Adult beetle and larval mines in lodgepole pine. About natural size. (*U.S. Dept Agr. Bur. Entomol. Plant Quar. Photo by Keen.*)

is to be found. These both have the elytra somewhat sulcate. In the pine forests along the California coast *A. nitidum* Lec., a larger and smoother species, appears; and in the Sierra Nevada Mountains a somewhat less smooth species *A. mokelumne* Csy. takes its place. The genus *Megasemum* (*Nothorhina* Csy.,) somewhat similar to *Asemum* but with the species more elongate and the antennae coarsely pubescent, has but one valid species in this country, *M. aspera* (Lec.) It is moderately elongate, subcylindrical, with the sides of the prothorax roughened or asperate and of a dark reddish-brown color. It ranges

from British Columbia through the Rocky Mountains and throughout the Cascades and Sierra Nevada Mountains, being most frequent in the fir forests. *Criocephalus* Muls. is similar in form to the preceding except that the species are generally broader and flatter. The eyes are large, coarsely granular, and not hairy. The best known species are *C. productus* Lec., a rather long and delicate species, common in most parts of the Pacific slope; *C. asperatus* Lec., a larger and more robust species, with the sides of the prothorax subangulate and strongly roughened and asperate, found with the preceding; *C. agrestis* (Kby.), a species similar to *asperatus* but with the sides of the prothorax more rounded and but slightly roughened, found in the Great Lakes region and eastern Canada; and *C. obsoletus* (Rand.), a somewhat subcylindrical species having the pronotum finely punctured and the third segment of the hind tarsi distinctly bilobed, found here and there along the Atlantic Coast. The two Pacific Coast species are often found flying very late in the autumn. The genus *Tetropium* Kby. has the eyes divided and rather finely granulated. The species are shorter, less robust, narrower, and generally smaller than are the members of the preceding genera. *T. cinnamopterum* Kby. is somewhat flattened, quite rufous in color, about 12 mm. in length, and found throughout eastern Canada and the border states of our country and extending well into the regions toward the northeastern part of the continent. *T. velutinum* Lec., a larger and velvety black or piceous species with the basal part of the elytra a lighter color, is found along the Pacific Coast from British Columbia to middle California. It breeds in the Douglas fir and pine and is sometimes a serious pest to the larch and hemlock. It is known in some localities as the western larch borer. A related species, *T. abietis* Fall, somewhat longer and of a more uniform brown color, replaces this species in the Cascades and Sierra Nevada Mountains where at times it does considerable damage by attacking and killing weakened true fir trees.

Following the Asemini in the system of classification are a number of tribes of cerambycid beetles which contain species that are in the main twig or branch borers. Few of these are of great economic importance, however. To the genus *Oeme* Newn. belong three species of elongate, slender, brownish beetles. *Oeme rigida* (Say) attacks cypress and juniper in the Eastern states; *O. costata* Lec. attacks pines in the Southwest; and *O. strangulata* Horn occurs in cedar and juniper in the same region. They cause particular injury to rustic work. In the tribe Hesperophanini, we have in the Atlantic region *Chion cinctus* (Dury), a moderately large, light-brown beetle, the elytra with apical spines and a number of transverse crescentic lighter markings. It is a species that does considerable damage to hickory lumber while it is

being cured. Several species of the South American genus *Eburia*, characterized by having series of short, ivory lines near the base and apex of the elytra, are also to be found in our territory, and some of these may, like *E. quadrigeminata* Say, which bores in ash, do some damage to curing timber. On the Pacific Coast, two species of *Brothylus* Lec.: *B. gemmulatus* Lec., a brown insect somewhat over 12 mm. in length with minute asperities or tubercles over the surface; and *B. conspersus* Lec., a clouded-gray species, are to be found. The first breeds in dead live oak, and the second in all species of white oak as well as the canyon live oak, *Quercus chrysolepis*, and the Oregon ash. Ash logs curing in the open are often so badly riddled by *B. conspersus* Lec. and by *Neoclytus conjunctus* (Lec.) that they are worthless for anything but firewood. The tribe Elaphidionini contains numerous genera and species, chiefly confined to the South and Southwest, many of them long, narrow, brown or gray twig borers of little importance, while others are of considerable size and might possibly do considerable harm to the curing timber of the oaks and other broadleaved trees in which they breed, if they were used for other than fuel purposes.

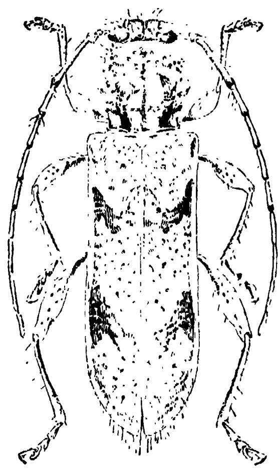

FIG. 82.—*Brothylus conspersus* Lec. × 4.

The tribe Lepturini is a large one and contains species that are characterized by a number of distinctive features, the principal ones of which are the following: conical front coxae with cavities angulate externally, middle coxal cavities widely open externally, the palpi unequal, eyes generally prominent, antennae inserted well in front of eyes, neck long, and mandibles acute and fringed on the inner margin. Many of the members have the afterbody quite cuneate; are often gaily colored, the color pattern due in great part to the variously colored pile; and are, in the main, flower frequenting. Many live as larvae in coniferous trees, others in the broadleaved trees or shrubs, and most mine the sapwood or heartwood of the larger limbs and main trunks. As such they are dominantly forest scavengers and injure only such timber as is allowed to remain too long cut in the forest before being lumbered. Only a limited number of the more important genera and species will be discussed.

The genus *Stenocorus* Lam. (*Rhagium* Fab.) is represented in the Old World by a number of species but in North America by but a few.

S. lineatus Oliv. is quite common and widely distributed, being found in most of our coniferous forests. The adult is somewhat over 12 mm. in length, black mottled with reddish brown and gray, with rather short antennae, the prothorax laterally acutely tubeculate, and the elytra tricostate. It is one of the first of the family to emerge, being on the wing in the early spring at Monterey, Calif., and in May or June in the mountains of the interior. The larvae are big-headed, rather broad and hairy, and are always to be found beneath the bark of dead trees. The first year they wander here and there beneath the bark, eating out broad, flat burrows and leaving a large amount of frass behind them. Later they make a cell by building up an elliptical barrier of frass, in which they spend much of their time and in which they transform to pupae and adults. Whenever this peculiar subcortical cell is found one may know what insect is at work, for no other American cerambycid larvae have this habit. They are found about practically all species of pine and perhaps attack certain other coniferous trees, for females apparently ovipositing in western hemlock and fir have been seen on Mount Hood in Oregon. They are much in evidence in proper localities but are not considered injurious, as they do not attack living trees and as larvae do not burrow deeply into the wood of the trees but confine their work mostly to the cambium and outer sapwood. The only harm that they could do would be through loosening the bark and allowing moisture and mold more readily to reach the solid wood.

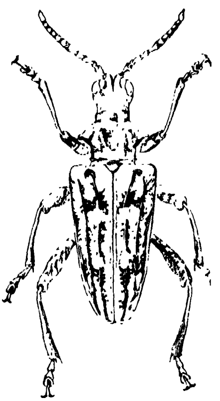

FIG. 83.—*Stenecorus lineatus* Oliv. × 2.33.

Leptalia macilenta (Mann.) is a rather small and delicate insect, slightly more than 6 mm. in length. In Alaska the more typical uniform, slaty-colored phase is to be found; but farther south in Oregon and California yellow and black vittate phases are to be met with. In Alaska this insect breeds most commonly in dead alder, from which Kincaid reared the material that served as the basis for his life-history study. It also has been taken from willow and in middle California from the California laurel, where it may do considerable damage in the way of hollowing out large cavities.

The genus *Pidonia* Muls. also contains species of small size and elongated form with narrowed prothorax. Our two western species are *P. gnathoides* (Lec.) and *P. scripta* (Lec.), the former somewhat infrequent, the latter common in our Pacific Coast coniferous forests. The former is very variable in color, generally with reddish testaceous

elytra marked with a black spot at the middle of each elytron, though sometimes almost entirely piceous, especially the males. The common *P. scripta* has testaceous elytra marked with fine arcuate and straight lines. The adults frequent the flowers of forest shrubs like the rhododendron, azalea, and wild rose. It is believed that both species breed in decaying Douglas fir. A well-known black and testaceous vittate species, *P. aurata* (Horn) is very common in the higher southern Alleghenies, as is also *P. ruficollis* Say, a black species with or without a red prothorax.

Gramoptera Serv. contains small species also but with the prothorax definitely companulate. The two best known species are *G. molybdica* (Lec.) and *G. subargentata* (Kby.); the first is of a shining greenish or bluish color, often with red humeri; and the latter black-clothed with short, gray pile giving it a silvery appearance. Both frequent flowers as adults. *G. molybdica* is common throughout the Pacific States and has been reared from the dead and decaying parts of alders, buckeye, and California laurel, while *G. subargentata* in its typical phase is a northern insect ranging from British Columbia to Maine and in modified forms found farther south along the Rocky Mountain, Cascade, and Sierra Nevada ranges. These latter are considered as distinct by Hopping and Swaine (1928), but extensive field observations have convinced Van Dyke that they are but subspecies.

The genus *Leptura* L., as now limited, is characterized by having a somewhat triangular or cuneate prothorax with the hind angles acutely produced over the humeri and contains but a small number of very graceful insects which are, however, very numerous and evident in our forests. The majority are to be seen as adults feeding in flowers where they mate, but they develop in the larger limbs and main trunks of our forest trees and to a great extent in the Coniferae. The females when laying their eggs are rather shy and as a result are rarely seen in connection with their food plants. The larvae are readily obtained in numbers from almost any dead or decaying timber. The best known Pacific Coast species are *L. anthracina* Lec., *L. plagifera* Lec., *L. propinqua* Bland., and *L. obliterata* Hald. The first is a black, somewhat shining species averaging about 18 mm. in length and found throughout the higher Cascades of Oregon and the Sierra Nevada Mountains of California. The second, *L. plagifera*, a somewhat smaller and narrower species, is black but generally with most of the outer and posterior parts of the elytra red; it ranges commonly along the eastern flanks of the Cascades and Sierra Nevada Mountains from British Columbia to northeastern California and has also at times been found farther afield, as along the middle Sierra and even

in the San Bernardino Mountains, as well as in the northern Rocky Mountains; it has been bred from the ponderosa pine by both Hopping and Craighead. *L. propinqua* Bland, a species somewhat similar in size to the preceding, is black, and the elytra testaceous but marked with a subbasal and a median lateral spot and black apices; it is common throughout the higher mountains of the entire Pacific slope; it has been reared by Craighead from Engelmann spruce but probably also breeds in the true firs. *L. obliterata* Hald. is perhaps the most common species of the genus along the Pacific Coast; it breeds in the following types of trees: *Abies*, *Picea*, *Tsuga*, *Pseudotsuga*, and various species of *Pinus;* the species breaks up into two distinctive color phases, each of which is confined to its own area in the more southern parts of its area of distribution. The typical form is black, with the sides and base of the prothorax testaceous, the elytra testaceous with a subbasal and subhumeral spot, a median transverse band, and the apices black or sometimes with the apices reddish and with a subapical black spot. This ranges from British Columbia south to Oregon, then becomes limited to the coastal area and as such extends south to middle California. The variety *soror* Lec. differs in lacking the subbasal spot and the reddish patch at the elytral apices. It is found in the north with the preceding and even extends into the northern Rocky Mountains but from middle Oregon south becomes restricted to the Cascades and Sierra Nevada Mountains. These beetles do not attack living trees or even recently felled timber, therefore do no harm to lumber provided the logs are milled within a reasonable time after being cut. If the logs are allowed to remain in the forest for a long time before being utilized, they may be not only severely infested but very much injured.

The genus *Anoplodera* Muls. is a very large one in North America, containing the majority of the species formerly placed in the genus *Leptura*, from which its species are separated in the main by having the prothorax companulate or quadrate and the hind angles not prolonged over the humeri, though they may vary from acute to laminate or even be obtusely rounded. The majority, though by no means all of the species, frequent flowers as adults, and they breed in various types of trees, the broadleaved as well as the conifers. Only a few of the more common species will be discussed. *A. brevicornis* (Lec.) is a moderate-sized, rather sooty-black species, with the prothorax conspicuously companulate, the hind angles laminate, the antennae short and slightly claviform in the female, longer and distinctly serrate in the male. It is not infrequent in the high middle Sierra Nevadas, probably extending as far north as Washington, and has been reared by Blaisdell from the stump of

Abies magnificá. *A. nigrella* Say is black like the preceding, though a color phase *praestans* Csy. with testaceous or reddish elytra occasionally occurs. The species differs primarily from the preceding by having the pronotum abruptly constricted at the apical margin and the basal transverse impression with abrupt sides. It is common in eastern Canada and the Great Lakes region, ranging west to British Columbia and Washington. Its known host trees are *Pinus*, *Picea*, and *Pseudotsuga*. *A. matthewsi* Lec., with the pronotum broad at middle and elytra testaceous with a large black patch near the middle and clouded apices, is a species that is found along the Pacific Coast from British Columbia to middle California. In the north it breeds in red cedar, *Thuja plicata*, and probably other cupressineous trees. It is also one of the characteristic insects of the dense redwood forests of northwestern California where it breeds in the sapwood of the fallen monarchs. *A. instabilis* Hald., in its usual color phase—black with the elytra testaceous and marked with a narrow basal, a postbasal, a median, and an apical black band—is found widely distributed throughout the forested areas of western North America and has been listed as from eastern Canada and New Hampshire but probably in error. It varies greatly in color throughout its range, all black phases being moderately common at times as in the Yellowstone National Park and the San Bernardino Mountains of California. The adults are most frequently to be found feeding on the lupines. Hopping has bred it from ponderosa pine, but it probably breeds also in many other coniferous trees. *A. sexmaculata* L. is a less robust species than the preceding, with testaceous elytra marked with two subbasal spots, one close to the suture; a median spot or irregular band; and black apices. It is also a more northern species, ranging from Alaska to Maine and British Columbia, with a few strays working south into the Rocky Mountains and into California. It probably breeds in both spruce and the true fir. *A. barberi* Fall is similar to the preceding but all black, perhaps only a color phase of that species. In Humboldt County, California, it breeds in the tideland or Sitka spruce and in the high Sierras, where it is also to be found, probably breeds in the true firs. *A. tribalteata* Lec. is a rather small and narrow species, black, with the legs usually yellowish and the body more or less clothed with yellow pile, the elytra being transversely barred with four yellow bands. It is a very common species in the mountains of California and extends north into British Columbia. *A. cordifer* (Oliv.) is a species somewhat like *A. instabilis* but with the spots more definitely united across the suture into bands. It replaces the latter in eastern North America. *A. impura* Lec. is a small and uncommon species, rufotestaceous, with two indistinct lateral elytral

spots. It is chiefly interesting because it, like *A. matthewsi*, breeds in the sapwood of the redwood, *Sequoia sempervirens*. It also breeds in the *Librocedrus* in the Sierra Nevada and probably other cupressineous trees. *A. laeta* Lec. is much like *A. tribalteata* but larger and generally more robust, with quite stout reddish antennae and legs and the black elytral bars generally much narrowed at the suture, the median usually broken there. It has been reared from oak by Downes. It is found throughout the Pacific Coast. *A. nitens* Forst., a closely related species with the antennae slenderer and generally darker and the median elytral band as a rule broad across the suture, replaces *laeta* on the Atlantic slope. It has been reared from various species of oak as well as from hickory and chestnut. *A. crassipes* (Lec.) is a widely distributed and at times common species throughout most of the Pacific slope. It averages about 12 mm. in length, has an elongate prothorax, definitely narrowed in front and slightly sinuate at sides posteriorly, is black, conspicuously clothed with golden pile, with yellowish or piceous antennae, testaceous legs and elytra, the latter with a small subhumeral spot in males, extended inward to form a bar in females, a conspicuous transverse patch at middle, not reaching suture, and a complete subapical and apical bar. The adults are very common on the flowers of yarrow and various compositae, and the earlier stages are passed in a miscellaneous series of trees such as the sapwood of the redwood, several species of pines, the California laurel, and *Eucalyptus*. The related *A. crassicornis* (Lec.), which has the lighter areas reddish rather than testaceous and the antennae and legs much more robust, seems to be limited to the very high Sierra Nevada. It has been bred from *Abies concolor* by McClay. *A. tibialis* (Lec.), also somewhat similar but with the pronotum subopaque, is a more northern species which dwells in the territory between the Great Lakes and British Columbia and farther north. It probably also breeds in the fir. *A. behrensi* (Lec.), a somewhat more elongate species, with the scutellar and humeral lobes of the elytra poorly developed and the yellow patches at the middle of the elytra in the female joined to form a C-shaped blotch, ranges along the Pacific Coast from Mendocino County, California, to British Columbia and in the north extends inland to the Cascades. It breeds in the Sitka spruce and undoubtedly several other trees. *A. valida* (Lec.) is a large species, averaging 20 mm. or more in length, elongate and subcylindrical, testaceous, the elytra generally with a subhumeral and two median black spots. It is found throughout western Oregon, Washington, and British Columbia and extends south along the Sierra Nevada Mountains. It has been reared from *Pinus ponderosa*, *Tsuga*, and *Abies*, the last its

most common food tree. *A. aspera* (Lec.), a moderate-sized, sooty black and roughly granular species, reared from *Betula* by Craighead, is to be found in the territory from Alaska to British Columbia and Colorado. *A. laetifica* (Lec.), a sexually dichromatic species, the males either entirely black or black with testaceous markings, the females with brilliant red elytra spotted with black, is common throughout the Pacific states, the adults frequenting various meadow flowers. It has been reared from various species of pines. *A. proxima* (Say), a moderate-sized, robust species with the dorsal surface somewhat flattened and black, with brownish-yellow elytra tipped with black, is one of the commonest species in northeastern North America. It has been reared from various broadleaved trees such as the maple, hickory, chestnut, and linden. A closely related western relative is *A. chrysocoma* (Kby). This species has the elytra broader at base and is more definitely cuneate. It is black, the elytra testaceous or piceous and densely clothed with a beautiful yellow pile. It breeds in most of the pines found within its range which is from the Pacific Ocean to the Rocky Mountains and in the north to the Atlantic Ocean. *A. canadensis* (Fab.) is one of the most attractive members of the genus and also one of the most variable. The typical phase is dull black, with the base of the elytra a bright red, the upper surface coarsely punctured, the antennae long, serrate, and generally annulated with yellow. This is the usual phase in eastern Canada and the adjacent parts of northeastern America. Farther west there is a tendency in the specimens for the red areas to become more extensive and for the general surface to be more shining, also to become larger and generally more robust. In the race *cribripennis* (Lec.), the elytra are entirely sanguineous, and the punctures of the elytra coarse and cribrate. The race *ebena* (Leng) is similar but entirely black. These larger forms are generally to be found in the Rocky Mountains and the Pacific Northwest. The species breeds in various pines, spruces, and the hemlock.

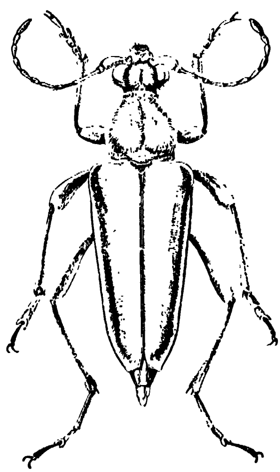

FIG. 84.—*Anoplodera chrysocoma* (Kby). × 3.

The genus *Centrodera* Lec. differs from the genera just discussed by having the hind tarsi with a brush of hair beneath, large and coarsely granular eyes, and tibiae with terminal spurs. The beetles are, in general, much elongated, especially the prothorax. *Centrodera*

nevadica Lec., our best known western species, is of a uniform light chocolate brown, sparsely clothed with short white pile. It breeds in the larger branches of dead ponderosa pine and ranges throughout the mountains of California. There are other species in the genus, both east and west, but these are far less common.

The genus *Toxotus* Dej. is somewhat similar in appearance to the last, but the elytra, as a rule, are broader and more angulate at base and have the tibiae with the spurs arising anterior to the apices. Most of the species are of large size, 12 mm. or more in length, most often uniformly reddish or brown in color, though some are black, others black with yellow vittae. The common Pacific species, *Toxotus vestitus* Lec.; may range in color from red through brown to black, bivittate or partly red and partly black. It is widely distributed and at times very common on flowers. *T. flavolineatus* Lec. is a very large black species with a yellow vitta on each elytron. It is found in the high northern Cascades and other mountains of the Pacific Northwest. *T. trivittatus* Say, a smaller species with quite similar markings, ranges from eastern Canada west as far as the Rocky Mountains. The more common eastern species other than *T. trivittatus* are *T. cinnamopterus* Rand., a rather small and more or less uniformly reddish or reddish yellow species; and *T. schaumi* Lec., a large black species with bicolored legs and abdomen either yellow or black.

The genus *Pachyta* Zett. is, in the main, boreal. It is characterized by having the prosternum broadly excavated across the middle, the front of the head oblique, tibial spurs terminal, hind or true wings with a closed cell in the anal region, antennae slender, eyes large, finely granular and emarginate, the pronotum with sides distinctly tuberculate, and the tarsus cleft to about the middle. The species are confined to the coniferous forests of the northern parts of both the Old and New World. They are, in the main, robust, broad across the base of the elytra, and generally with the latter yellow or straw colored, often barred or blotched with black. Our commonest species is *P. liturata* Kby., in which the females have the elytra straw colored, with dark apices or entirely black, and the males more reddish elytra as well as longer antennae. It is common from eastern Canada to British Columbia and north as well as in the high mountains of the west and is generally associated with the true firs. *P. armata* Lec. is a broad and attractive species with bright yellow elytra tipped with black and is restricted to the Rocky Mountains of Idaho and the Cascade Mountains of Washington and Oregon as well as found in British Columbia. The adults frequent the flowers of the mountain ash or rowan, *Sorbus sitchensis*. The well-known *P.* (*Parapachyta*)

spurca Lec. is a much larger and more elongate species, entirely straw colored except for a black spot on the elytra. It is common throughout the Pacific Coast, breeds in the Douglas fir, and frequently flies to light.

A related genus is *Anthophilax* Lec. which differs mainly by having the hind tarsi cleft to the base. The best known species are *A. tenebrosus* Lec., a much roughened, all-black species, confined to the high Cascades and Sierra Nevada Mountains, and breeding in both fir and mountain hemlock; *A. mirificus* Bland, a species simulating the preceding as regards the female, though with the basal half of the elytra rugose and the apical portion finely granular or sericeous, while the males have the elytra a bright red marked with black, confined to the Rocky Mountains; and *A. attenuatus* (Hald.), a species with dull-red elytra marbled with patches of white pile, found throughout the Great Lakes region and eastern Canada. *A. malachitus* (Hald.) and *A. viridis* Lec. are black with brilliant metallic-green elytra found in the same region as the last and extending through the Alleghany Mountains, while the beautiful, more roughened, bronze and green *A. hoffmani* Beut. is confined to the high mountains of North Carolina. These latter, like the former, prefer the true firs as host trees.

The genus *Gaurotes* Lec. is a more widely dispersed genus. The species are much shorter and stockier than the preceding and have the true wings without a closed cell in the anal region, the pronotum obtusely rounded at the sides, the episternum of the metathorax broad at base, and the eyes entire. They are smooth and shining, the more northern species black, with the elytra a brilliant metallic green. *G. cressoni* Bland. has the legs orange barred with black and is restricted to the mountains of the West. It breeds in the Douglas and true firs and the adults frequent the flower of the wild parsnip, *Heracleum*, honeysuckle, etc. The related *G. cyanipennis* (Say) with black abdomen; and *G. abdominalis* Bland, with a red abdomen, are found in the eastern states, the former quite common.

The genus *Acmacops* Lec. contains species that are somewhat similar in facies to the preceding. They are short and robust species, generally of a black, yellowish brown or somewhat metallic color, and found as adults on flowers. As a rule, they frequent the flowers of the meadows or more open places. The food plants of most are unknown, but others, like the common *A. pratensis* (Laich.) and *A. protens* Kby., which are both more or less polychromatic, black marked with yellow, all black, or all yellow, are widely distributed throughout the more northern and mountainous parts of the country and breed in various types of coniferous trees, chiefly the true firs. The species

of the more open country are supposed to breed either in the stems or in the roots of annuals.

The genus *Evodinus* Lec. differs from *Gaurotes* chiefly in having the eyes distinctly emarginate. The only species, *E. monticola* (Rand.), is generally black, with straw-colored elytra, patched with black. It is, however, quite variable as to color, some races, as those from the mountains of North Carolina, being almost or entirely black, others with yellow legs, etc. It is a northern species, very suggestive in its coloration and form of some of the species of *Anoplodera*. It ranges south on the Atlantic seaboard through the Alleghany Mountains and in the West follows south along the Rocky Mountains and Cascades. It breeds in true fir and, on the Pacific Coast, also in Douglas fir. The adults are generally to be found in flowers, having quite a fondness for those of the azalea.

Though the genus *Desmocerus* Serv. belongs near the Lepturini, the species are quite different in appearance from the usual type found in that tribe, being much more cylindrical. They are restricted to North America and breed only in the roots or stems of the various species of elderberry, *Sambucus*. They average 18 mm. or more in length, have rather large, serrate antennae, and are generally conspicuously colored. In the late spring or early summer the adults may often be seen resting on the foliage of their food plant, where their large size and conspicuous coloration make them evident. It is supposed that they are distasteful to birds. *Desmocerus palliatus* (Forst.), a black species with the elytra one-half blue, the other half yellow, is a common species in eastern North America. *D. californicus* Horn, a more robust species, black or bluish black, with the elytra margined with red in both sexes, is found throughout middle and southern California and breeds in the blue-berried elderberry. *D. dimorphus* Fischer is but a subspecies of this, the males having much of the disk of the elytra yellow. It is to be found only about Sacramento, Calif. *D. cribripennis* Horn, a smaller and more cylindrical species, of a somewhat greenish color with red margins to the elytra, is a more coastal species, extending from British Columbia to San Francisco Bay. It breeds only in the red-berried elderberry. *D. piperi* Webb is but a subspecies of the preceding, differing chiefly by having the males with entirely red elytra. It is a more inland form, found in the high Cascades at Crater Lake, Oregon, the Blue Mountains of Washington and Oregon, and extending as far east as Glacier National Park. *D. auripennis* Chev. is much like a larger form of the preceding, bluish black, the females with the elytra margined with red, and the males with the elytra entirely bright red, fading to yellow after death. It is confined to the high Sierra Nevada Mountains.

The two North American genera of the tribe Necydalini differ from most of their allies by having the antennae very long and the elytra much abbreviated, thus exposing the greater portion of the true wings and giving the insects a very wasplike appearance. *Ulochaetes leoninus* Lec. is large, black and yellow, and quite hairy, somewhat suggesting a bumblebee. It breeds in old stumps and the basal portions of trees, as a rule, though it may also live in the main trunk of fallen timber. It prefers the ponderosa and jeffrey pines, the true firs, and the alpine hemlock. A common place to find the female is on an old blaze or base burn of a large fir. The species is confined

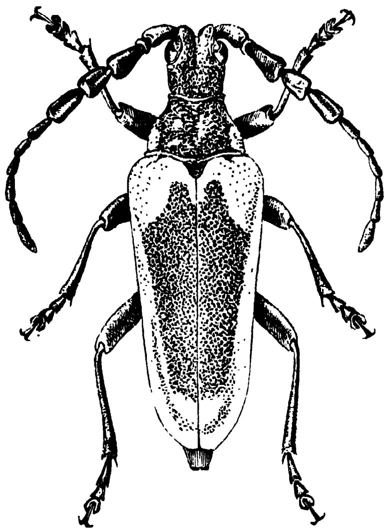

FIG. 85.—*Desmocerus auripennis* Chev. × 2.

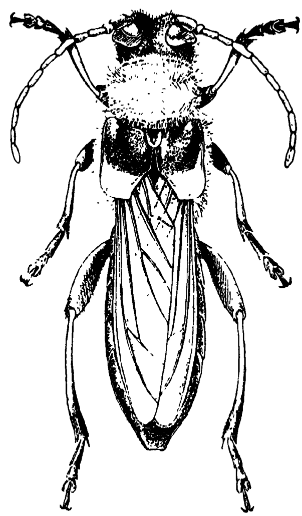

FIG. 86.—*Ulochaetes leoninus* Lec. × 2.

to the Pacific Coast, especially to the Cascades and Sierra Nevada Mountains. The members of the genus *Necydalis* are much smaller, averaging 12 mm. or more in length and quite narrow. *N. mellita* Say is the smallest species, of a pitchy color, and rather uncommon in eastern North America; *N. cavipennis* Lec. is somewhat larger, dark brown or reddish, ornamented with golden pile, and confined to California where it breeds in the *Eucalyptus*, oak, and various other broadleaved trees; while *N. laevicollis* Lec. is a narrower and more glabrous species, black or reddish in color, and found mostly along the coastal region of northern California and Oregon. Our other species, *N. barbarae* Rivers, a large red species of the Santa Barbara region; and *N. acutipennis* Van D. of northern California, are very rarely seen.

TRIBES CALLICHROMINI AND COMPSOCERINI

The genus *Callichroma* Latr. our only member of the first tribe, is mainly tropical—Mexican and South American. A few species are, however, found in our more southern and border states. They are very large species, 25 mm. or more in length, with the tibiae of the hind legs broad and flattened. Most of the species are of a deep-blue or dark-green color above; but one, *C. melancholicum* Bates, which crosses into Texas from Mexico, is sooty black. They are flower frequenting as adults. In the second tribe we also have one genus. Its single species in North America is *Rosalia funebris* Mots., a large black-and-white species with very long, annulated antennae. It is one of the best known and most attractive of our Pacific Coast longhorned beetles. It breeds in the ash in the state of Washington, in the California laurel in California, and generally in the willow east of the Sierra Nevada Mountains. This beetle is blamed to a great extent for the hollowing out of the trunks of many of our larger laurel trees.

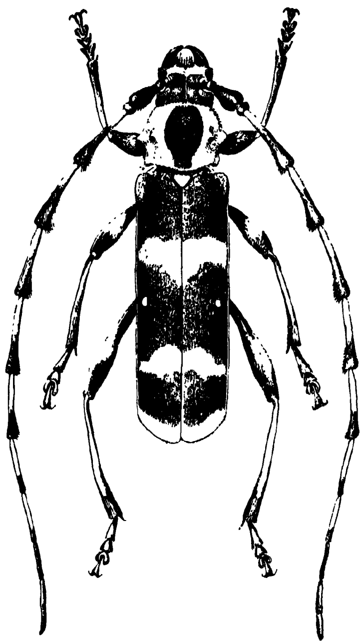

Fig. 87.—*Rosalia funebris* Mots. × 2.

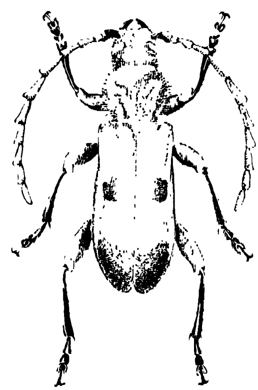

Fig. 88.—*Semanotus ligneus* (Fab.). × 3.

The tribe Callidini is of moderate size, containing some of the most characteristic genera of the more northern parts of the world. The beetles are more or less flattened, the legs with large femora, thus enabling them to wedge themselves beneath the bark of dead trees. The larvae are, in the main, cambium borers. Only a few of the more important ones will be mentioned.

The cypress bark borer, *Physocnemum andreae* Hald., is a rather large, robust, reddish-brown beetle, the larvae of which cause much damage to felled and girdled cypress in the south. In the genus *Semanotus* we have in *S. ligneus* (Fab.) a species 12 mm. or more in length, black, the elytra with orange markings on a light background. In the Eastern part of our country it breeds in dead juniper but on the Pacific Coast splits up into several subspecies, one breeding in the junipers and incense cedar, *Libocedrus*, others in the red cedar, *Thuja*, cypresses, and even in the coast redwood, *Sequoia sempervirens*. *S. litigiosa* Csy. somewhat simulates the preceding, the females with the elytra orange and black, the orange markings often much reduced, the males usually entirely black. It is a very variable species, ranging from Maine across the continent, extending well north through Canada, into the Rocky Mountains and along the high mountains of the Pacific Coast. It breeds commonly in the various species of true fir, appearing on the wing in early summer often before the snow is off the ground. *S. amethystinus* (Lec.) is somewhat larger, of a shining black, with brilliant-blue elytra. It is the most characteristic insect of the post cedar, *Libocedrus decurrens*, the beetles early attacking the trees after death, and the larvae with their broad burrows soon separating the bark from the sapwood. *Callidium* Fab., the typical genus of the tribe, contains numerous species. *C. antennatum* Newn. is a bright-blue species, over 12 mm. in length, with large black antennae in the male and, in well-developed individuals, a depressed, amphora-like area on the disk of the prothorax. It breeds in numerous species of pines along the Atlantic seaboard, on the West Coast as the subspecies *hesperum* Csy,; it also breeds in pines but it is here often quite destructive in lumber yards, the larvae boring through an inch or so of the wood below the bark. *C. pseudotsugae* Fisher is of about the same size as the preceding but a dull black. This bores in the Douglas fir throughout the coastal areas of California but in the Sierra Nevada, also in the true firs—in fact having a preference for the latter. Several slightly smaller and brighter blue species also breed in various species of juniper; and one, *sequoiarum* Fisher, also lives in the California red-

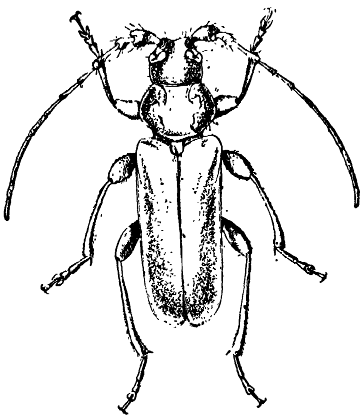

FIG. 89.—*Callidium antennatum* Newn. × 3.

wood. *C. hirtellum* Lec. is a very small, yellowish or rarely black species found commonly on the small branches of dead ponderosa pine throughout the Pacific Coast. Other species are either rare or of little economic importance. *Phymatodes* Muls. is a large genus containing many small, flattened species. The most often seen of these are *P. dimidiatus* (Kby.), a black species with the basal area of the elytra reddish, found widely distributed throughout the more northern parts of the continent and breeding in firs and spruces, as a result often annoying in log houses; *P. varius* (Fab.), a rather dull-black species with two divergent ivory-white lines on each elytron, common on various coniferous trees throughout eastern North America; *P. decussatus* Lec., a somewhat similar species but with the prothorax and elytra a reddish yellow, confined to the white oaks in California; *P. nitidus* Lec., a smooth and shining species colored similarly to the preceding, living in the small branches and twigs of all types of cupressineous trees, as well as the junipers and sequoias in western North America; *P. vulneratus* Lec., another Pacific Coast and similar bicolored species yet with only one white line on the elytra, which breeds in the broadleaved maple and Oregon ash; and *P. obscurus* Lec., a somewhat larger, uniformly dull-brown species breeding freely in most species of Pacific Coast oaks.

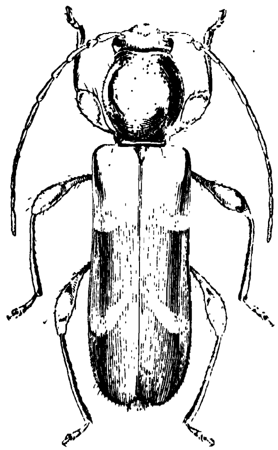

Fig. 90.—*Phymatodes nitidus* Lec. × 6.

The large tribe Clytini, world-wide in distribution, contains beetles that are, in general, cylindrical in shape, often barred or ornamented with patches of yellow or white pile, giving them a wasplike appearance. Many frequent flowers as adults; others are to be seen only coursing up and down the stems of their food trees. *Megacyllene antennatus* (White) is an attractive light-brown beetle with transverse white markings, 12 mm. or more in length and with long, annulated antennae, found widely distributed throughout our Southwest and northern Mexico. It breeds in all species of the mesquite and at times does considerable damage. *Cyllene* Newn. is a tropical American genus, black, the elytra more or less angulately bared, and with long antennae. Of the species to be found in our territory, only three will be mentioned. The first is *C. crinicornis* Chev., a species with the base of the prothorax suddenly constricted, found commonly in Mexico, though crossing our southwest border. This breeds freely

in the species of mesquite. It has also been introduced into the Hawaiian Islands, where it is of considerable economic importance, not only living in the introduced algeroba or mesquite which is now widely distributed but also attacking several other trees. *C. caryae* Gahan attacks the dead or dying hickories of the Eastern states. It is a spring insect and injurious only to curing timber. The third species, *C. robiniae* (Forst), the locust borer, is, however, an insect of major importance, attacking not only the injured but healthy trees. The adults appear in the autumn, assemble, and mate on the flowers of the goldenrod; then the females seek out a host tree, the black locust, which may be one previously attacked or one that has its trunk exposed to the full glare of the sun. These insects are sun lovers like most of their kind and rarely attack trees that have their trunks properly shaded by lower branches. The larvae upon hatching bore upward beneath the bark, causing it to crack, then as they get larger bore directly into the heart of the trunk or branch, as the case may be. Ultimately, they bring about the death of the tree. The wood is, of course, also rendered useless. The best control, according to some workers, is to have the trees grown in dense stands and with plenty of shade for the trunk and larger branches. *Glycobius* (*Plagionotus*) *speciosus* Say, the maple borer, is a somewhat larger insect, nearly 25 mm. in length, with rather short antennae, the prothorax large and transversely barred with yellow, and the elytra marked with large, oblique bars of yellow. It is well-known throughout our Northeastern states, attacking the hard or sugar maple. It generally attacks through wounds, such as the V-shaped cuts formerly made for collecting the sugar; areas where the bark had been chewed off by horses, as on the trees along the roadside in former days; and wounds caused by nailing barbed wire or fence rails to the trees. The genus *Xylotrechus* Chev. is a large one containing insects of moderate size, short antennae, and especially characterized by having a V-shaped callosity or smooth area on the front of the head. The best-known species are *X. colonus* (Fab.), a black and gray species, breeding in various oaks and hickory in eastern North America; *X. undulatus* (Say), a black species marked with fine white or yellow, undulating transverse

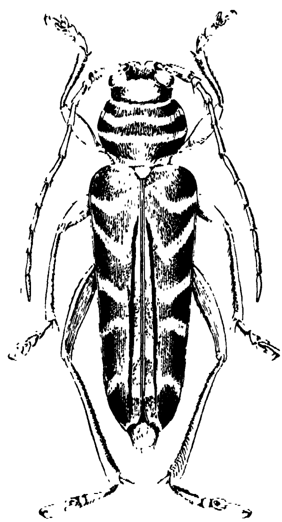

FIG. 91.—The locust borer, *Cyllene robiniae* (Forst.). × 2.

lines on the elytra, breeding in both firs and spruces, and widely distributed through the more northern and northwestern parts of the country; *X. annosus* (Say), a gray species marked with transverse white bands, breeding in all species of poplar and widely distributed from the Lake states to British Columbia and down the coast to northern California; *X. nauticus* (Mann.), a pitchy black species with very fine, often interrupted and wavy transverse lines on the elytra, breeding in most of the California live oaks, black oaks, and overlapping on to the introduced *Eucalyptus*, cultivated walnuts, and sometimes stone fruits of the orchard; and *X. insignis* Lec., the female a beautiful, sooty black with yellow, wasplike markings; the male, reddish with the elytra marked with basal and subapical patches of yellow, often the entire elytra sparsely clothed with yellow pile, and attacking only the willow as far as known and limited to California and Oregon.

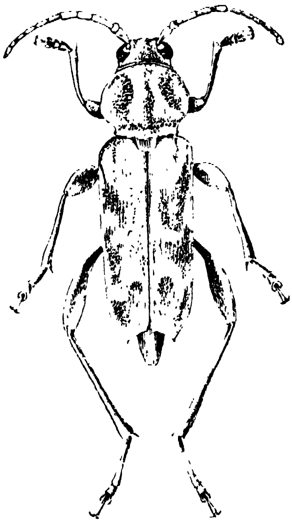

FIG. 92.—*Xylotrechus nauticus* (Mann.). × 3.

Neoclytus Thom. is also a large genus, with the prothorax longitudinally compressed or subcarinate above, the antennae short and more or less clubbed, and the legs quite long. These zebra-colored beetles are, in general, quite delicate, and most species are rare in collections. Among the better known are *N. muricatulus* (Kby.), a small, black species with narrow, sinuous, white bands on the elytra, common from the Lake states and eastern Canada west to the Pacific and south to middle California, and breeding in the twigs of the Douglas as well as true firs; *N. conjunctus* (Lec.), a species about 12 mm. in length, with either white or yellow markings on a black background, and found breeding on the Pacific Coast in Oregon ash, the various kinds of white oak, madrone, and manzanita, a species that is at times of considerable economic importance; *N. balteatus* Lec., a large and

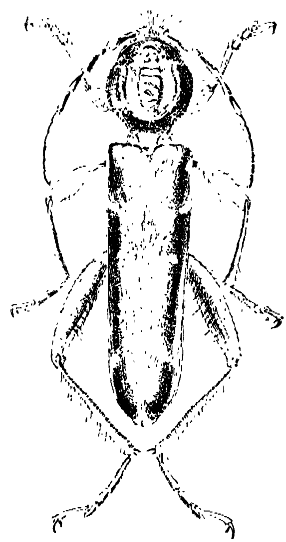

FIG. 93.—*Neoclytus conjunctus* (Lec.). × 4.

narrow red species barred with yellow, generally taken on the manzanita or madrone in southern Oregon and California; and the well-known *N. caprea* (Say), a black species with broad, yellowish bands, found in Arizona as well as all of eastern North America where it bores in ash. In the typical genus *Clytus* Laich., shorter and more compact as well as more wasplike because of the broad transverse yellow bars, we have several species, two of which might be mentioned. *Clytus marginicollis* Cast. lives in northeastern America, and *C. planifrons* Lec. in the mountains of California.

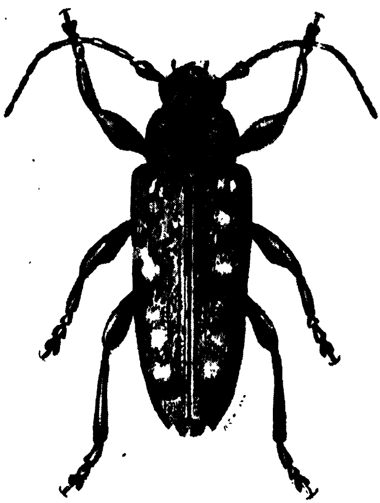

FIG. 94.

FIG. 95.

FIG. 94. *Atimia dorsalis* Lec. × 6. (*Muzzall.*)
FIG. 95. *Paratimia conicola* Fish. larva in cone of knobcone pine. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Photo by Patterson.*)

They breed in the branches of the true fir, the latter also in those of the Douglas fir.

The small tribe Atimini, contains but two genera and six species, yet it is of considerable importance. *Atimia* Hald. contains five species: *A. confusa* (Say) of the Atlantic seaboard, *A. dorsalis* Lec. and *A. helenae* Lins. of the Pacific states, *A. huachucae* Champ. & Knull of Arizona, and *A. mexicana* Lins. of southern Mexico. They are all rufous or rufopiceous species, irregularly clothed with gray pile which gives them, especially *A. huachucae*, a spotted appearance. They all breed in juniper or the various cupressineous trees, *A. dorsalis* being at times quite common about dead *Libocedrus*. *Paratimia conicola* Fisher, a smaller and narrow insect, of an orange-brown color

lined along the suture with white, breeds as far as known only in the cones of the knobcone pine, *Pinus attenuata*.

SUBFAMILY LAMIINAE

The members of this subfamily are to be separated from those that precede by having the prothorax not margined on the sides and the front tibiae obliquely grooved on the inner surface, also often with the outer part of the tibiae somewhat rotated on the basal part. The species are practically all nocturnal, non flower frequenting, generally somber in color, and to be found only about their food trees.

Two species only need be mentioned of the tribe Dorcadiini of wingless beetles. *Plectrura spinicauda* Mann. is a rather small, black or brownish-black species with the apices of the elytra spiniform and the disk ornamented with tubercles and spines. This species is moderately common in the dense woods of the Pacific Northwest and, according to Hardy and Preese, breeds in alder, willow, and maple. *Ipochus fasciatus* Lec. is a short, robust beetle with an elliptical after-body, of a brownish-black color, irregularly patched with gray hair. It is found throughout southern California and ranges north along the coast as far as Santa Cruz County. It generally breeds in oak, but adults are also to be found on willow, *Ceanothus*, and various other shrubs, indicating that they probably also breed in these plants.

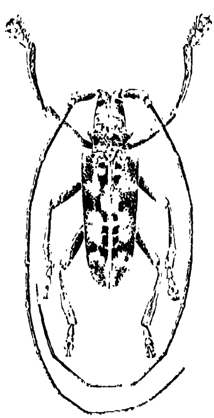

FIG. 96. The spotted pine sawyer, *Monochamus maculosus* Hald. Natural size.

There is but one genus, *Moneilema* Serv., of the tribe Moneilemini, but it is of fair size The species are all of medium or even large size, very robust, black, and wingless. They all breed in the various species of cactus and are to be found throughout northern Mexico and our own Southwest. As much as they breed in the living plants, they serve somewhat as a control and for that purpose have been introduced into Australia with the hope of reducing the amount of unwelcome cactus there.

Several of the genera in the tribe Monochamini are of considerable economic importance. *Monochamus* Serv., the species of which are called sawyers or timbermen, is the most important, all of our species being of large size, 25 mm. or more in length. All of the North American species breed in coniferous trees. *Monochamus titillator* (Fab.), the southern pine sawyer, is a common eastern and southern species, of a reddish-brown color, marbled with white and brown.

M. confusor Kby. is larger than the preceding, from 37 to 50 mm. in length, of a clouded-gray color, and rather limited to northeastern North America. It readily attacks logs or dying or weakened pine, spruce, and fir. *M. maculosus* Hald. is a large black species marbled with white. It is found in the Eastern part of our country but is more common on the Pacific Coast where it attacks dead and dying pines of all types. At lower and hotter levels among the digger and knob-coned pines, it becomes lighter in color, thus closely simulating the eastern *M. titillator*. *M. scutellatus* (Say), a black beetle, with white scutellum and elytra more or less flecked with white, is common throughout the Alleghany region, most of the northern part of the continent, and in the coniferous forests of the Pacific slope, where it becomes larger in size and almost entirely black, the subspecies *oregonensis* Lec. It breeds in fir, spruce, the Douglas fir, and white pine. *M. marmoratus* Randall is of a reddish gray to black with the prothorax somewhat marked with ocher near the lateral spines, and the elytra marbled with brown. It is a common species of eastern Canada and Maine. All of the beetles attack the trees soon after they are felled, and in a few months the larvae are well-established within the heartwood. As a result, logs left on the ground long after the summer months suffer severely. The best methods of control are to have the timber milled as soon after the trees are felled as possible or at least to get the logs off the ground and into the mill-pond without delay. *Ptychodes trilineatus* (L.) is an elongated black species with white stripes along the suture of the elytra, which often attacks the fig in the Southern states. *Dorchaschema wildi* Uhler is a marbled-gray beetle with very long antennae, destructive

FIG. 97.—Cerambycid larvae, *Monochamus maculosus* Hald. and their work in trunk of Douglas fir. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Photo by Patterson.*)

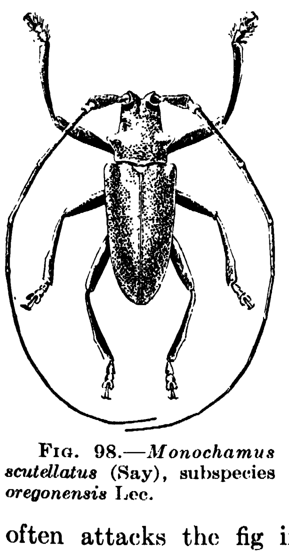

FIG. 98.—*Monochamus scutellatus* (Say), subspecies *oregonensis* Lec.

at times to the mock orange. The members of the genus *Goes* Lec. are often pruners, the adults removing a circular cuff of bark from the limb before depositing their eggs. They also attack the trunk of living trees. *G. tigrinus* DeG., a large, clouded-gray beetle, is, according to Packard, the most common borer in hickory and in walnut in the southern states; it also attacks oak. *G. pulcher* (Hald.), a brown beetle about 25 mm. long, with a transverse light band across the elytra, is a common enemy of hickories, doing at times great damage to the pecans in the southern states. *Plectrodera scalator* (Fab.), a large black beetle with large patches of white scattered here and there over its surface, is moderately common throughout the Middle West.

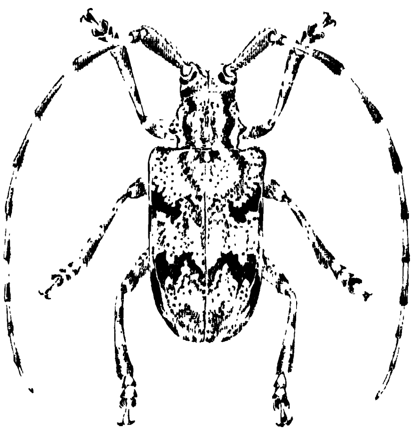

FIG. 99. *Synaphaeta guexi* (Lec.). × 2.

It is called the cottonwood borer and is very destructive to willows as well as poplars, attacking the living trees.

The only species in the tribe Mesosini in our territory is *Synaphaeta guexi* (Lec.), a large and broad, somewhat flattened black beetle densely clothed with gray and black pile, the latter forming two narrow longitudinal lines on the pronotum and two broad, zigzag, and interrupted transverse bars across the elytra. This species is widely distributed along the Pacific slope, breeding in many types of trees such as the poplar, buckeye, maple, box elder, alder, walnut, eucalyptus, and cherry. It is at times quite destructive, the larvae gradually working their way through old broken limbs and wounds into the main trunk, ultimately killing the tree.

The tribe Acanthocinini contains a considerable number of genera, some with many species. They are all of rather small size, often with a pretty design and generally very long and delicate antennae. Most of them breed in the twigs or smaller branches. The

bulk of the species are restricted to our Eastern and Southern states, and most of them live in the hardwoods. On the Pacific Coast, there are but few species: *Leptostylus nebulosus* Horn, a small and compact gray beetle, ornamented with a clouded design, which breeds in various species of true firs; *Leropus barbarus* Van D., a longer, flatter species found breeding in dead live oak in the Santa Barbara region of California; and *Hyperplatys asperatus californicus* Csy., a small, spotted, flattened species which breeds in the twigs of several trees including the cultivated cherry and walnut.

The members of the tribe Graphisurini are 12 mm. or more in length, rather flat and narrow, with a somewhat variegated pattern on the elytra and exceedingly long antennae. In the typical genus *Graphisurus* Kby. the females have the last abdominal segments prolonged to form an ovipositor. The two well-known Pacific Coast species are *G. obliquus* Lec., a smaller gray species with a wavy design on the elytra, and *G. spectabilis* (Lec.), a larger species, 25 mm. or more in length, with the pattern more blotchlike. They both breed in the ponderosa and other species of western pines, mainly boring in the twigs and smaller branches. They often lay their eggs in the holes made by scolytid beetles and may sometimes do some damage by enlarging an old lightning blaze. In such cases the larvae are to be found working just beneath the bark. In eastern North America there are also several other species as well as several in the related genus *Urographis*.

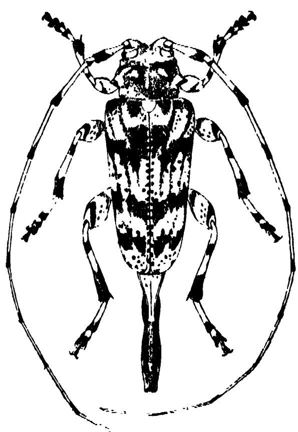

FIG. 100. *Graphisurus spectabilis* (Lec.). × 1.33.

The tribe Pogonocherini includes beetles that are, in general, short and compact and generally very hairy. They cling to old dead twigs, and so closely does their gray color pattern harmonize with their surroundings that they are hard to detect. The principal genus *Pogonocherus* Latr. has recently been restudied by Linsley, and many of the species placed in new genera. The two common eastern species *P. mixtus* Hald. and *P. parvulus* Lec., however, remain in the old genus. The first is small, rather flattened, and gray spotted with black and ocher, with the apices of the elytra emarginate, and breeds in both coniferous and broadleaved trees. The second is quite similar but smaller and generally more northern in distribution, chiefly in Canada. It seems to breed only in the willow. Most of the western North American species with rounded elytral apices

have been placed in the genus *Poliaenus* Bates. Of these, *P. californicus* Schf., a light-gray species with crescentic ridges of tufted hair, breeds in the *Fremontia;* while *P. schaefferi* Linsl., a gray species with black, lateral, triangular markings, breeds in the ponderosa pine; and *P. oregonus* Lec., a gray species with a broad belt of black across the middle, seems to be confined to the Douglas fir and true firs. *P. penicellatus* Lec. is found in spruce twigs. There are numerous other species, but they are less evident in the forest.

FIG. 101.—Larva of *Graphisurus spectabilis* (Lec.), feeding through the inner bark of ponderosa pine and destroying the mines of the western pine beetle. × 1.25. (*Photo by Keen.*)

The tribe Onciderini is important chiefly because of the genus *Oncideres* Serv. which contains a number of rather cylindrical, gray species transversely barred with lighter bands and often ornamented with tufts of colored hair scattered over the surface. All of them have the bad habit as adults of biting out a cuff of bark around a twig so as to cause its death, thus providing suitable food for their larvae. These twigs break off during the fall or winter months; and when the beetles are abundant, considerable pruning results. The best known species are *O. cingulatus* (Say), the oak girdler of eastern North America; *O. pustulatus* Lec., the mesquite girdler of Texas; *O. putator* Thoms., the somewhat similar mesquite girdler of Arizona; and *O. quercus* Skinner, the oak girdler of Arizona.

In the tribe Saperdini, though it contains in our fauna only the typical genus *Saperda* Fab., are to be found several of our most important and destructive species. They are all characterized by being elongate, parallel-sided, somewhat flattened above, with the front of the head vertical, the legs strong, and the body rather densely clothed with closely applied pile. Our largest, perhaps most important, species is the poplar borer, *Saperda calcarata* Say, an insect 30 mm. long, of a light-grayish color with a limited amount of buff and chalky patches of considerable size. It attacks the living poplars of all types but is most destructive to the aspens and ranges in the north from the Atlantic Ocean to a little west of the Rocky Mountains and south as far as Texas. It is especially common on the aspens in the Rocky Mountains, enters eastern Oregon, and has been taken in California. About three years is required for it to complete its development. It generally enters the tree low down and bores upward, keeping the burrow more or less open by continually expelling the frass and oozing sap from the lower opening. Often the work is confined to the sapwood areas, causing the bark to become rough and cracked; but in the aspens it as often bores into the heartwood. In time the trees succumb. The beautiful *S. candida* Fab., a smaller, light-brown species with broad white stripes down its elytra, is perhaps one of the most famous insects of eastern North America. Dubbed the roundheaded apple-tree borer, it has figured extensively in economic entomological literature. It attacks apple trees in old, neglected orchards, also sometimes ornamentals, but its native host is the hawthorn, the various species of *Crataegus*. It is confined to the Atlantic states. A related species, *S. cretata* Newm., has the white markings in the form of large blotches on its wing cases. Though it is found in New England, it is more common in the Lake states where it does considerable damage, taking the place of *S. candida*. *S. tridentata* Oliv. is a smaller and darker species with several reddish, oblique lines on its elytra. It is limited to northeastern America and confines its attacks to the elm, hence is often called the elm borer. As a rule, it first attacks the limbs, later the main branches and trunk where it bores beneath the bark or in the outer sapwood. The hickory is also attacked by several species, as *S. discoidea* Fab., the female gray with darker disk, the male a more uniform dark-slate color; and

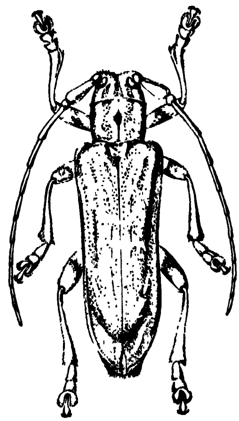

FIG. 102. The poplar borer, *Saperda calcarata* Say. × 1.33.

S. lateralis Fab., a brown species with red margins. These insects are not so harmful as some of the preceding species, as they rarely attack a tree before it has been very much weakened by other causes. The second species generally attacks close to the roots. On the Pacific Coast are to be found but two species: *S. horni* Joutel and *S. populnea* (L.). The first is something like *S. calcarata* in appearance but smaller and with a pronounced groove between the bases of antennae. It is found throughout California and breeds in the willow, sometimes doing much damage by entering the tree in the neighborhood of dead areas and causing these to be greatly extended. The true *S. populnea* is not found in America, but several subspecies as *moesta* Lec. and *tulari* Felt and Joutel are, the first commonly in the Lake states and adjacent parts of Canada, the latter on the Pacific Coast. All are small, more or less gray, spotted with brown, *tulari* sometimes quite fulvous, and they breed in the branches of various species of poplar, causing the formation of long, fusiform galls with the ultimate death of the branch, thus bringing about a large amount of pruning and distortion.

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CHAPTER VII

THE BEETLES (*Continued*)

OTHER FAMILIES OF BEETLES

In the two preceding chapters the families of beetles responsible for most of the insect damage in the forest have been discussed. In this chapter other families commonly found in the forest will be considered, some of them doing considerable damage to forest trees or products, others of great importance because of their predaceous habits. Many others while not particularly harmful or beneficial are listed here because they are so frequently seen by those who are collecting or studying the insects found in the forests. In this chapter the beetles are discussed more in their systematic order, rather than in the order of their importance.

PREDACEOUS GROUND BEETLES

As indicated by the common name, the majority of these beetles, family Carabidae, are terrestrial. Here they exert a very important role, feeding as they do in both the larval and adult state upon practically all types of small animal life. On the forest floor as well as under the bark and within the crevices of rotting trees numerous species are to be found. These feed on such insects as Thysanura and Collembola, termites, the caterpillars and pupae of moths and sawflies, and the early stages and the adults of the plant-feeding Coleoptera. They are thus one of the active agents of control in their allotted environment. A few of the Carabidae are arboreal, especially in the more open forests and in the tropics. Under the bark of dead trees in our northern forests certain small carabids like *Psydrus piceus* Lec., *Tachyta nana* (Gyll.), *T. falli* (Hayw.), and *Tachymenis flavicauda* (Say) are to be found and even in the mines or runways of burrowing species.

The forest caterpillar hunter, *Calosoma sycophanta* L., is the carabid that has attracted most attention among our forest entomologists. It was first successfully introduced into Massachusetts from Europe in the year 1906 for the control of the gypsy moth, *Porthetria dispar* L. The beetle averages 37 mm. in length by almost 16 mm. in breadth and is of a bluish-black color with brilliant-green or somewhat golden elytra. The adults emerge from hibernation about June 1 and soon

mate, the females laying their eggs during June and July. The egg stage lasts from 3 to 10 days; the larval, about a fortnight; and the pupal, almost as long. The beetle after reaching maturity remains in the old pupal cell, overwinters there, and does not emerge until the following June, appearing at the same time as the older adults from their hibernating quarters, for these beetles may live as long as 4 years. During both the larval and the adult periods, the beetles are exceedingly voracious, attacking and feeding on great numbers of the larvae and pupae of the gypsy and browntail moths, tent caterpillars, and other types of Lepidoptera as well as upon the larvae and pupae of sawflies. The larvae as well as the adults readily climb the trees in search of their prey, a rare trait among the larger Carabidae, and as a result are that much more efficient as destroyers of noxious caterpillars.

We also have many native species of *Calosoma*, some in every part of the country, but most of these are to be found in the more open areas where they prey upon cutworms and other lepidopterous larvae. Some of them are at times of great value in controlling the outbreaks of certain caterpillars in brush lands and even in the forest.

Burgess and Collins, 1915.

ROVE BEETLES

The rove beetles, family Staphylinidae, are generally elongated, with well-developed, sickle-like mandibles and very short elytra. They are usually very active and often run with the abdomen curled up over the body; hence the common name of devil's-coachhorse in England. They are eminently predaceous. The larvae are, in habits and appearance, much like the adults, differing chiefly in being without wings and in having the body softer and lighter in color. Both larvae and adults feed mainly on the larvae of flies, though they will readily attack the eggs and larvae of other insects. They are especially abundant in the damper parts of the Northern Hemisphere and are always to be found about rotting fungi and other types of decomposing vegetable matter; dead animal matter; in close proximity to ponds, lakes, and streams; and along the seacoast.

In the forests they are fairly abundant, chiefly on the ground, though many species are attracted to the numerous fungous growths or the souring areas beneath the bark of dead trees. Many of the species to be found in such situations are supposedly of considerable economic importance. These are often to be found in the runways of various Scolytidae where they supposedly feed on the eggs and larvae. The following will serve as an example.

The genus *Nudobius* Thom. is distributed throughout the coniferous forests of the Northern Hemisphere, all stages of the various species being found beneath the bark of dead or dying trees. The best known of the species found on the Pacific Coast is *Nudobius pugetanus* Csy., generally distributed throughout the ponderosa pine areas from British Columbia to middle California. It is from 7.7 to 9.2 mm. in length, brownish black, shining, the elytra a clear rufous throughout, and the legs pale straw-colored. According to Struble (1930), there is but one complete life cycle a year and no regularity with regard to the development of the species, both larvae and adults overwintering in old dead trees. The adults, upon the opening up of the season, will fly to trees that have been killed the previous year, mating there during the early summer. Their progeny will complete their development before the winter and overwinter as adults. The overwintering larvae will change to adults during the late spring, and these will fly to the trees that have been quite recently killed. Their progeny will not reach maturity before the winter so will pass through the winter in the larval stage. On the Atlantic slope a related species *N. cephalus* (Say) is to be found.

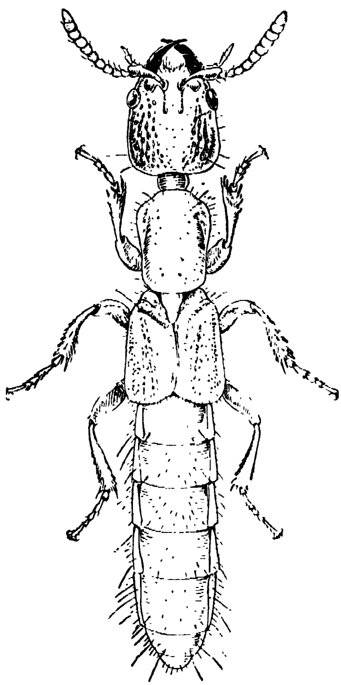
FIG. 103.—*Nudobius pugetanus* Casey. × 10.

Casey, 1906; Struble, 1930.

LADY BEETLES

The lady beetles, family Coccinellidae, have long been known as friends of man, and all but a limited number such as the members of the genus *Epilachna* Chev., mainly confined to the tropics, well merit his high opinion. They are generally small or of moderate size, hemispherical or elliptical in shape, and usually of a reddish or yellowish color spotted or ornamented with black or black marked with red, yellow, or white. Both larvae and adults of most of the species are eminently predaceous, feeding on plant lice and scale insects, though able to adapt themselves to other types of food like pollen when their usual prey is less abundant. Many of the species are rather restricted as to the species of insects upon which they live,

therefore more or less definitely localized to certain types of plants, while others are more general feeders and more widely distributed. As a result of these habits, these beetles undoubtedly do an immense amount of good by keeping in check, to a greater or lesser degree, many kinds of plant lice and scale insects. Many species are to be found in the forest.

The convergent lady beetle, *Hippodamia convergens* Guer., is one of the most widely distributed of the family and on the Pacific Coast without doubt the most common. The beetles are elliptical in shape, average 7 mm. in length, are black with reddish elytra, the head more or less white, the pronotum margined with white and with two convergent white lines on the disk, and each elytron marked with six black spots as well as a common scutellar mark. The larvae are elongate, grayish in color, and marked with several orange spots. During the fall these beetles congregate in certain areas in enormous numbers and banked up against old logs or beneath the pine needles pass the winter there. With the first warm days of spring or early summer, they emerge from their winter quarters and by degrees spread out over the country, in the mountains gradually drifting up to the higher levels as summer advances. This species feeds mainly on the plant lice of shrubs and herbage.

The five-maculated lady beetle, *H. quindecim-maculata* Muls., is the common species in the more northern parts of the country. In this species each elytron has a lunate black mark near the base, joining its fellow at the suture; an irregular black spot near the apex; and a more or less curved bar slightly in front of it. This species is often found congregated in great numbers about the rocks at the summits of our mountains. Numerous other species of the genus are to be found distributed throughout the country, but they are not strictly forest insects, being confined more to the low herbage, though often in close proximity to the forest.

The pine lady beetle, *Cleis* (*Harmonia*) *picta* (*Rand.*), is to be found throughout the pine and fir forests of the country. It is somewhat smaller than the members of the preceding genus, oval, rather depressed, black with orange legs, the head yellow with two interrupted black lines, the pronotum black spotted with yellow, and the elytra yellow without spots in the male; in the female, generally with an anterior and posterior black bar extending outward from the suture to unite with a longitudinal streak beyond the middle of each elytron. This species is quite variable, breaking up into a number of diverse color races in the different parts of the country. It is common on pines but frequents the true firs as well and at times is very abundant. It is an aphis-feeding species.

Rathvon's forest lady beetle, *Anatis rathvoni* Lec., is one of the largest beetles of the family, generally distributed throughout the Pacific Coast wherever the true firs are to be found. It is almost 8 mm. in length, very broad, rather convex, black, the head with two white spots, the pronotum with a narrow anterior margin, broad lateral margin, irregularly incised near the hind angles, and two divergent white markings near the base, the elytra yellowish or reddish brown with humeral black spots and seven black or ocellate spots arranged in two transverse series, one medially, the other posteriorly. The larvae are black, variegated with yellow, and about 15 mm. in length when full-grown. They live on the large black aphis.

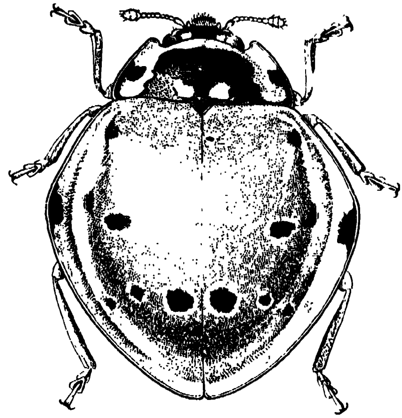

FIG. 104.—Rathvon's forest lady beetle. *Anatis rathvoni* Lec. × 7

The fifteen-spotted forest lady beetle, *A. quindecimpunctata* (Oliv.), replaces this species in the Eastern part of the country. It is quite similar in size and general appearance but with the sides of the elytra less angularly explanate and the spots larger and more eyelike.

LeConte's lady beetle, *A. lecontei* Casey, in the Rocky Mountains, is a species somewhat larger, fully 10 mm. in length, and with the elytra a bright brownish red, without discal spots but with a distinct black lateral margin.

The species of the genus *Neomysia* Csy. are almost as large as the preceding and generally found, like them, on the true firs. They are, as a rule, of a straw color and with longitudinal interrupted lines on the elytra instead of spots. *Neomysia subvittata* (Muls.) is the largest and most common species on the Pacific Coast, and *N. pullata* (Say) the best known along the Atlantic Coast. The latter has the elytral markings often quite obscure.

The genus *Scymnus* Klug contains a very large number of quite small, somewhat hairy and hemispherical black or brownish lady beetles, most of which are to be found restricted to the forests. Some, like the coal-black *Scymnus ardelio* Horn of California, prefer the pines, while others frequent the oaks and other broadleaved trees. All are scale feeding. The genus is a very important one economically, for both larvae and adults are voracious and generally numerous.

The twice-stabbed lady beetle, *Chilocorus bivulnerus* Muls., a beetle 2 to 3 mm. in length, of a shining-black color, with an irregular red spot about the center of each elytron, is the best known member of a peculiar group of lady beetles which are characterized by being of medium or even small size and with the elytra more or less flattened and explanate at the margins, so that they are able to cling very closely to any surface. These beetles are generally of a shining-black color spotted or marked with red and are to be found on shrubs or broadleaved trees in the more open parts of the forest. The twice-stabbed lady beetle, like its fellows, is scale feeding and most beneficial.

Crotch, 1873; Forbes, 1883; Horn, 1895; Casey, 1899; Leng, 1903; Essig, 1910; Palmer, 1914; Clausen, 1916; Boving, 1917; Timberlake, 1919; Gage, 1920.

CYLINDRICAL BARK BEETLES

The more typical members of the family Colydiidae are narrow, elongated, and somewhat cylindrical beetles. They are generally dull in appearance, reddish or brownish in color, and often very beautifully sculptured on the upper surface. The less typical species are more flattened, generally gray in color, and often with the hairy vestiture arranged in tufts. These latter generally feed on fungi, and their color pattern is for purposes of enabling them to blend with their surroundings. The members of the first group are all believed to be to a great degree predaceous, as they are generally to be found in the burrows of the various wood-boring beetles.

Deretaphrus oregonensis Horn is our largest species, 11.5 mm. in length. It is narrow and much elongated, very irregularly sculptured, and of a dirty-black color. According to Burke (1919), it lives in the tunnels of various wood-boring beetles and has been proved to destroy the larvae and pupae of *Dendroctonus jeffreyi* Hopk. and *D. monticolae* Hopk., *Trachykele opulenta* Fall, *T. nimbosa* Fall, *Buprestis aurulenta* L., and *B. laeviventris* (Lec.), as well as *Asemum atrum* Esch. It is found throughout the pine forests of California and Oregon. The larvae are elongated, whitish, small-headed, with well-developed legs and recurved hooks at the apex of the abdomen. They are one of the few beetle larvae which are able to spin a cocoon in which to pupate.

The genus *Lasconotus* Er. is composed of small, elongated, and markedly sculptured beetles generally to be found in the runways of the Scolytidae. All of the species of which there are over twenty are confined to North America. Most of these are to be found about coniferous trees. *Lasconotus complex* Lec. is one of the largest, about 4 mm. long, reddish brown, flattened, with four irregular, longitudinal

ridges on the pronotum and the alternate intervals of the elytra developed into well-marked ridges, four to each elytron, with a double row of well-impressed punctures between each. It is widely distributed over the Pacific Coast, being found mainly in the burrows of the genus *Ips* and on the coastal pines like the Monterey, Bishop, and beach pines as well as in the interior on the ponderosa and Jeffrey pines. Other species of *Lasconotus* are found on the same trees as well as on the various types of cedars, and at least one species seems to be confined to the oaks.

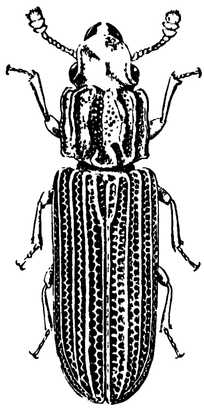

FIG. 105.—*Lasconotus complex* Lec. × 12.5.

The genus *Aulonium* Er. is found in Europe, Tasmania, and South America as well as North America. In our country there are but four species, *A. longum* Lec. alone restricted to the Pacific slope. It averages 6 mm. in length by 1.5 in breadth, is quite flattened, with lateral sinuous ridges and a pair of elongate median tubercles on the pronotum, the elytra minutely punctured and with finely punctured striae. It is generally to be met with in the tunnels of *Ips* and *Dendroctonus* beneath the bark of dead or dying ponderosa pine trees. The remaining species in our country are to be found in the southern states.

Horn, 1878; Casey, 1890, 1897; Kraus, 1912; Burke, 1919.

THE CUCUJIDS

The family Cucujidae is not large, but it contains certain members which are either very evident or destructive. The saw-toothed grain beetle, *Oryzaephilus* (*Silvanus*) *surinamensis* (L.) and its close relative *Cathartus advena* (Walh.) are very injurious to food products such as dried fruits and cereals. Other members which are to be found in the forest are generally quite flat and somewhat elongated and are supposed to be predaceous.

The largest and also most conspicuous member of the family because of its color, in this country, is *Cucujus clavipes* Fab. and its western subspecies *C. clavipes puniceus* Mann. This insect is much flattened and of a brilliant crimson color with antennae and tarsi black. It is widely distributed throughout the coniferous forests of the country. The western phase is most evident during the late autumn or early spring, generally found safely tucked away in a convenient crack or under the bark of a dead tree. The yellowish and flattened larvae are quite common during the summer months beneath the bark of dead trees, often in crude cells where they may be

seen transforming into pupae several months later. They are generally believed to be predaceous in the larval as well as the adult state.

The genus *Laemophloeus* Lap. contains many species, some like the cosmopolitan *L. pusillus* (Schon.) common in foodstuffs, but most are confined to the forest where they are to be found under bark or in the runways of boring beetles. They are all quite small, a few millimeters in length at the most, narrow or moderately broad, always much flattened, yellowish or brownish in color, sometimes with large spots on the elytra, and generally with large heads and very long antennae. They are thought to prey on the eggs and larvae of other insects, chiefly the destructive wood borers, and as such to be beneficial.

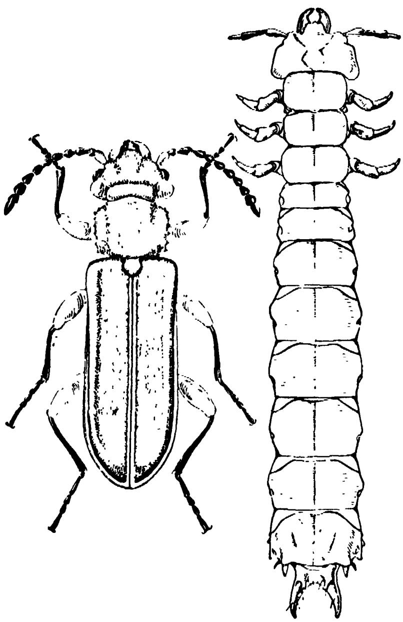

FIG. 106.—*Cucujus clavipes* Fab. and larva. × 3.

Casey, 1884, 1916.

THE SKIN BEETLES

Most members of the family Dermestidae are scavengers, the larger such as the typical genus *Dermestes* L. feeding on skins and drying carcasses, sometimes invading households to feed on carpets, furs, or dried meats. The smaller species are generally found during their early stages under the bark of dead trees or in similar retreats where they feed upon the remains of dead insects, the old drying larval and pupal skins as well as adults. Some of these occasionally get into insect collections where they create havoc. The adults of many also frequent flowers for the sake of feeding on pollen. Most of these beetles are somewhat elliptical in shape and more or less clothed with hair or scales which form attractive patterns.

Jayne, 1882; Casey, 1900, 1916*a*.

THE STEEL OR HISTER BEETLES

All of the members of the family Histeridae have the integument very hard and steel-like. Besides this, they have clubbed antennae and short, stout legs, which they can tuck away beneath themselves much in the same manner as turtles do. Thus protected they can

seek out their prey without injury to themselves. The more spherical forms like the species of *Hister* L. and *Saprinus* Er. are generally to be found about carrion where they prey upon the maggots or fly larvae, while the flatter or more cylindrical forms are to be found in the forest beneath the bark of trees or in the burrows of wood-boring beetles, upon which they supposedly live.

The members of the genus *Hololepta* Payk. are generally of large or moderate size, elongate, parallel, very much flattened, black, and shining. They are to be found throughout the warmer parts of the world. In western North America the larger species like *H. yucateca* Mars. and *H. cacti* Lec. are generally to be met with in rotting yuccas, cacti, and similar succulent plants. The smaller species generally live beneath the bark of dead poplars and other types of broadleaved trees.

Platysoma punctigerum Lec. like the rest of its fellows in the genus is elongate, parallel, considerably flattened, and shining. It is 4 mm. in length, black, with two short apical striae near the suture and four complete striae to the outer side of each elytron. It is quite common in the egg channels of *Dendroctonus brevicomis* Lec. as well as other species of *Dendroctonus* and of *Ips*, beneath the bark of ponderosa pine. The larvae as well as the adults are to be found in the burrows where they no doubt feed on the eggs and larvae of the bark beetles. The adult *Platysoma* have been actually seen by Struble (1930) feeding on the adults of *D. brevicomis* Lec. The species is found throughout the Pacific Coast. *P. depressum* Lec., a somewhat shorter and broader species, is also to be found on the Pacific Coast as well as in the East and under pine bark, while several other species are confined to the East and South.

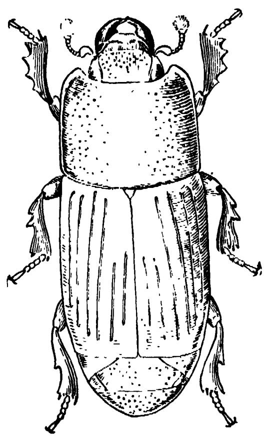

FIG. 107.—*Platysoma punctigerum* Lec × 12.5.

The species of the genus *Teretrius* Er., six of which are to be found in the United States, are somewhat smaller and more cylindrical than the members of the preceding genus. They frequent the burrows of the Ptinidae and Bostrichidae rather than the Scolytidae. *Teretrius obliqulus* Lec. has been found in the burrows of the lead cable borer, *Scobicia declivis* (Lec.) All of the species in another genus *Plegaderus* Er., are very small (the largest not more than 2.5 mm. in length) and but little elongated. They are quite numerous at times beneath the bark of dead pines, creeping about in the souring debris, no doubt in search of small maggots. Our commonest and largest species is

P. nitidus Horn, a shining-black species, looking like a small black bead when seen in its normal setting. This is supposed sometimes to feed on the eggs and young larvae of certain Scolytidae.

Horn, 1873; Perris, 1876; Casey, 1893; 1916*b*; Carnochan, 1917; Struble, 1930.

THE SAP-FEEDING BEETLES

The family Nitidulidae includes beetles of various forms, some of them elongated with sides parallel, others more or less elliptical in outline, but all are rather small, much flattened, generally brownish or straw-colored, with the elytra usually abruptly truncated behind and not completely covering the abdomen, the antennae short and clubbed, and the legs also short. They are, in the main, scavengers, living about carrion and in decaying fungi, souring fruit, or other decomposing vegetable matter. Many are to be found in the adult stage frequenting flowers for their pollen. Others are confined to the forests, living in the souring material beneath the bark of dead trees or in various fungous growths. Several species such as the members of the genus *Carpophilus* Steph. are of definite economic importance; a few members of this genus are injurious to dried cereals and other food products as well as to ripening fruit. The forest species are, on the whole, beneficial as pollenizers and scavengers, though some have been accused of carrying the spores of destructive fungi from diseased to healthy trees. The species of *Glischrochilus* Reit. (*Ips*) which are among the larger and more conspicuous members of the family are often to be seen beneath the bark of dead trees. They are from 4 to 8 mm. in length, shining black, and ornamented with yellow or red. Our western species are *G. fasciatus* (Oliv.), with two basal and two subapical yellow patches, a species that extends clear across the continent at higher latitudes; *G. vittatus* (Say), black with numerous short yellow streaks on the elytra, widely distributed throughout Alaska and the Pacific Northwest; and *G. cylindricus* (Lec.), with four red patches on the elytra, limited to the northern Rocky Mountains, Cascades, and Sierra Nevada Mountains.

Horn, 1879.

THE OSTOMIDS

The rather small family Ostomidae (Temnochilidae, Trogositidae) is decidedly dimorphic, containing two tribes, the Tenebroidini with species all more or less elongated, subcylindrical, and in most cases decidedly predaceous in both the larval and the adult stages; and the Ostomini with members more or less elliptical in outline, very much flattened, and generally fungous feeding in both larval and adult

stages. With the exception of *Tenebroides mauritanicus* (Linn.), the well-known cadelle, a destructive species in granaries throughout the world; and *Lophocateres pusillus* (Klug.), the Siamese grain beetle, a small, flattened species, introduced into this country from the Orient through commerce, all of the species of both tribes are to be found in the forest.

The genus *Nemozoma* Latr. in America is confined to the Pacific Coast, the species being quite small (4 to 5 mm. in length), very narrow and cylindrical, and with the head deeply longitudinally grooved in front. They are black or bluish black in color, with the base of the elytra yellowish; in one species the prothorax is also yellow. They dwell in the tunnels of *Pityophthorus* and other small Scolytidae upon which they prey. *N. attenuatum* Van D. is found on the Monterey and other coastal pines, ranging from Carmel, Calif., at least as far north as Washington; *N. fissiceps* (Fall.), a species with a yellow pronotum, is limited to the Sierra Nevada Mountains; while *N. punctulata* Van D. is widely spread in the region of the northern part of the Great Basin. The related genus *Corticotomus* Sharp which differs from the preceding by the head's being flattened in front and not grooved, also contains a number of species found on both sides of the continent. The beetles have habits similar to those of the above and are equally beneficial. *Corticotomus caviceps* (Fall) is the best known of the Pacific Coast species. It is bicolored like *Nemozoma* and is found widely distributed throughout the Rocky Mountains and the Pacific Coast. It is mainly to be found about the ponderosa pine. *N. parallelus* (Melsh.), a unicolorous brown species, is the best known of the species in eastern North America.

Temnochila Westw. is a genus containing long, subcylindrical beetles, 12 mm., or more in length and generally brightly colored, green, blue, or bronzed. Representatives are to be found in both the Old and New World, but they are most numerous as regards number of species in the Central American region. *Temnochila virescens chlorodia* (Mann.) has been selected as our representative of this important genus. It ranges in length from 10 to 18 mm. and is of a brilliant metallic-green or bluish-green color. It is well-armored and provided with powerful mandibles which enables it to crush with perfect ease any of the Scolytidae or other small forest insects. It is found throughout the forests of the entire Pacific slope, on oaks and other broadleaved trees as well as on most of the conifers. It flies well, sometimes in the hottest sun, but generally prowls like the weasel at night and because of its power and form is able to force itself readily beneath the bark of dead trees or into any crack which may offer a convenient retreat or lodge its prey. The larvae are elongate

and wormlike; averaging 20 mm. in length when fully grown; white but with the head, portions of the dorsal surface of the thoracic segments, and the anal segment black. They are provided with stout mandibles like the adults and have well-developed legs and a pair of hooklike processes on the last segment of the abdomen. They are to be found generally beneath the bark of dead trees, but they can gnaw their way readily through the wood itself so easily can secure an abundance of food. This species because of its voraciousness and predaceous habits in both larval and adult stages is one of the most beneficial insects in the forest, even though it takes a small toll of beneficial insects.

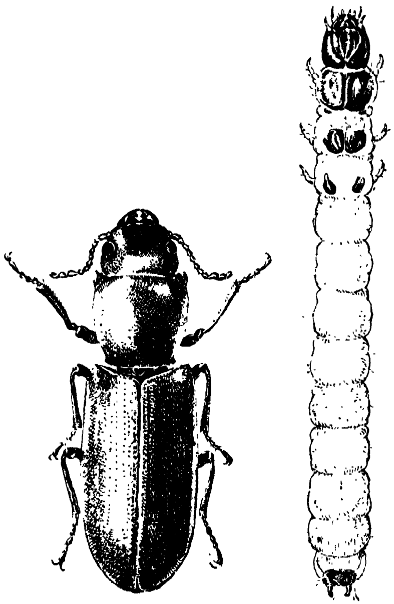

FIG. 108.—*Temnochila virescens chlorodia* (Mann.), × 4, and larva, × 3.2

The species of the genus *Tenebroides* Pill. & Mitt. are somewhat smaller than the above, flatter, and more somber in color —piceous or black. They are found in the forest chiefly beneath the bark of dead trees, often in places where the sap is souring. They vary in size as to species, ranging from 4 to 10 mm. in length, are generally unicolorous above, though they may be sometimes ornamented with light spots, and have habits somewhat similar to those of *Temnochila*. *Tenebroides mauritanicus* (L.) is the well-known cadelle, a cosmopolitan species found about granaries and one that feeds upon the grain itself.

The common *Calitys scabra* Thunb. belongs to the tribe Ostomini. It is longer than broad, with sides somewhat parallel, broad and flattened, about 10 mm. in length, of a dirty-brown color, and very roughly sculptured. It looks much like a small piece of bark. It is found throughout the Pacific Coast, more northern parts of eastern North America, as well as in Europe, and is to be seen about the brackets of woody fungi or beneath the bark of dead trees, especially when there is much fungous growth there. *Ostoma ferruginea* (L.) and *O. pippingskoeldi* (Mann.) are slightly smaller than the preceding, more elliptical in outline, and with the upper surface much smoother, the first entirely rufous and shining, the second a dark brown with lighter markings and somewhat dull in appearance. The first species

has a distribution similar to that of *Calitys scabra* Thunb., but the second is limited to the Pacific Coast, ranging from Alaska to California. Both live about woody fungi and beneath the bark of dead trees. Except for the fact that these beetles may carry the spores of injurious fungi to healthy trees, they would be looked upon as harmless insects.

Horn, 1862; Van Dyke, 1915; Casey 1916c.

SNAPPING BEETLES OR CLICK BEETLES

The family Elateridae is as truly characteristic of the forest as it is of the meadows and more open country. Many of the shade-loving species are root feeding in their early stages, just as are the majority of those of the meadows, but the greater number live in the dead timber, most as wood feeding species, though others are truly predaceous to a greater or lesser degree. The adults are elongate, generally with serrate antennae and with a prothoracic sternal spine which acts as a spring when forced into its receiving groove in the mesosternum and hurls the beetle into the air. The larvae are yellowish, long, and more or less cylindrical and often with a pair of hooks on the last segment. They are commonly called wireworms. The economic status of the forest species as a whole is that of wood scavengers.

The genus *Adelocera* Latr., one of the most typical of the timber species, contains elaters of a somber appearance, black or reddish brown, 12 mm. or more in length, somewhat flattened, with deep grooves along the margin of the prosternum for the reception of the antennae, and more or less definitely clothed with gray or golden scales. The adults may at times be found on the foliage especially of young ponderosa pines but are more often seen beneath the bark of fir or pine logs, especially during the early part of the season. Our common western species are *A. sparsa* Caud., sooty black with a sprinkling of white scales over the surface; *A. profusa* Caud., a somewhat broad species, with a broad, median pronotal impression and densely clothed with scales of various shades of brown; and *A. rorulenta* Lec. of a more rufous color, narrower and somewhat pointed behind, with the pronotal impression deep and narrow, and the scaly vestiture of a golden color. In the eastern portion of the country there are other species. The following are the best known: *A. marmorata* (Fab.), a black species simulating *sparsa* but larger; *A. brevicornis* Lec., a close but smaller relative of *profusa; A. impressicollis* (Say), a small brown species with the elytral punctures arranged in rows; and *A. discoidea* (Web.), a small, black species with golden scales margining the prothorax.

The genus *Alaus* Esch. contains some of our largest species. Representatives are to be found in most of the warmer parts of the world, especially in Africa and Asia. In North America the species are black or brown, variously spotted or clouded with white, and with two large, eyelike spots on the pronotum. The only Pacific Coast species is *A. melanops* Lec. This is from 25 to 30 mm. in length, black, with white scales sparsely scattered over the surface, the eyelike spots black with narrow white boundaries. It is to be found beneath the bark of dead ponderosa pines, chiefly the old, somewhat weathered stumps. The larvae when full-grown are close to 36 mm. in length, yellowish white, with head and thoracic segments more or less black. They are at times predaceous but in the main are lignivorous. Other species in the country are *A. oculatus* (L.), a very robust species simulating the preceding but of a more pronounced black with the markings more strongly contrasting, fairly common in many parts of eastern North America and generally to be found about dead broadleaved trees as the elm and linden; *A. myops* (Fab.), a narrower and more brownish species, living in old coniferous trees; and *A. lusciosus* Hope, a very large black species with chalky-white blotch markings, found in Texas and neighboring parts of the southwest.

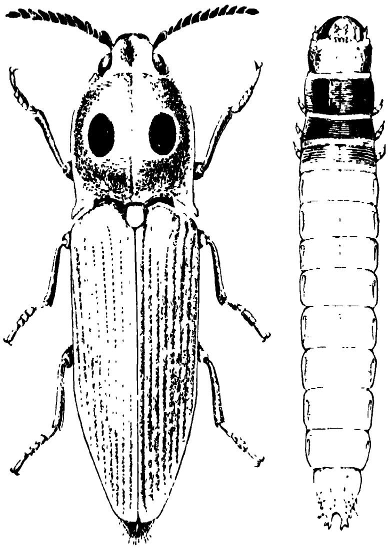

FIG. 109. *Alaus melanops* Lec., × 2 and larva, × 1.5.

The species of the genus *Elater* L. are numerous throughout the forested areas of the Northern Hemisphere. In North America there are over fifty species. They may be black, brown, or variously marked with red, orange, or yellow and range in size from 8 to 12 mm. in length. They are trimly built and have as their most distinctive features a convex head, clypeus with complete anterior margin, the gular sutures excavated in front, and hind coxal plates suddenly dilated inward. The adults are generally to be found during the early part of the season beneath the bark of dead trees and later somewhat widely scattered through the forests. The most common of our numerous West Coast species are *E. rhodopus* Lec., 12 mm. long, black species with ventral surface red and two well-marked

carinae on the hind angles of the prothorax; *E. nigrinus* Payk., a small, coal-black species common in the cooler Northwest; *E. cordifer* Lec., a black species with rich orange elytra on which there is an apical cordate black spot, common about dead white oaks and sycamores in middle and southern California; and *E. phoenicopterus* Germ., a black species with reddish-orange elytra, fairly abundant about old ponderosa pine logs. Numerous eastern species are also known such as *E. laesus* Lec. and *E. linteus* Lec., bicolored species common in coniferous forests; and *E. apicatus* Say, a species with reddish-yellow elytra and a small, black subapical spot, ranging from Maine to the Lake states.

Species of other genera of Elateridae such as *Ludius* and *Athous* are to be found in the forest, but only a limited number of these are ligniferous, most, in the early stages, developing either in very much decomposed logs or on the roots of grasses. The adults, however, often seek the shade of the forest.

Horn 1879; Le Conte, 1884; Hyslop, 1917; Schenkling, 1925, 1927, 1927*a*; Van Dyke, 1932.

THE CROSS-WOOD BORERS

The small family Melasidae (Eucnemidae) is very closely related to the preceding, the adults differing only by having the labrum concealed and the antennae somewhat distant from the eyes at their bases. They also lack the power of leaping, though they are very active and hard to capture. The larvae differ greatly from wireworms, being more wormlike, soft, and white, simulating the larvae of the Buprestidae somewhat when the thoracic segments are enlarged as is sometimes the case, though the apical segments are generally the most dilated. Their mandibles are toothed on the outer side, and they bore by moving their head from side to side and rasping rather than by nipping out the wooden particles. All members of the family are typical timber beetles, most abundant in the warmer parts of the world, but a limited number of genera and species are to be found in the more temperate regions of the North. In our territory there are twenty-five genera and about sixty species. Most of the genera have but one or two species, *Dromaeolus* Kies., *Fornax* Cast. *Microrhagus* Esch., and *Nematodes* Latr. being the only ones with numerous species. In western North America we have two species of *Melasis* Oliv., one *Isorhipis* Lec., the only American *Eucnemis* Ahrens., four species of *Dromaeolus* Kies., the only *Phoenocerus* Bouv., but one species of *Microrhagus*, *M. pectinatus* Lec., entering our territory in British Columbia. *Xylobius cylindriformis* Horn is a small, cylindrical, dark-brown beetle breeding in the sapwood of the

coast redwood and in both pines and firs. The keel-headed *Epiphanis cornutus* Esch. is found about coniferous trees throughout the Northwest, the large and beautiful crimson and black *Palaeoxenus dohrni* Horn about cone-bearing trees in the mountains of southern California, and the common *Anelastes druryi* Kby., is found everywhere in the coniferous forests. As far as known, the larvae of all mine either firm, dry wood or that which is soft and decaying. On the whole, they might be said to be timber scavengers.

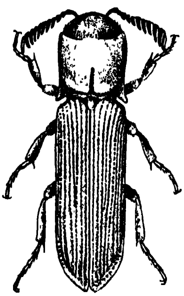

FIG. 110.—*Melasis rufipennis* Horn. × 3.5.

Melasis rufipennis Horn in the adult state is from 8.3 to 12.2 mm. in length, black with dull-red elytra and somewhat rufous antennae and legs, short antennae, those of the males quite pectinate and of the females merely serrate; the prothorax slightly wedge-shaped, broadest in front, with short, acute, and diverging hind angles, and the surface coarsely granular; the elytra with the striae well-marked and finely punctured, and the intervals finely granular; and the last ventral segment with a short, blunt spine. The larvae much resemble those of the Buprestidae, being somewhat longer than adults, legless, flattened, with the thoracic segments enlarged, a T-like marking on the first segment, both dorsally and ventrally, and the mandibles with well-developed external teeth. The mature beetles are to be seen about their host trees during the late spring or early summer, those in the higher mountains emerging later, as usual, than those in the lowlands. The females before ovipositing, unlike the Buprestidae and more typical Elateridae which merely lay their eggs in convenient cracks, bore a cylindrical tunnel straight into the trunk of the tree to the extent of several inches, in this regard simulating many of the Bostrichidae and ambrosia beetles. The larvae burrow transversely and, when numerous, more or less parallel with one another so as to honeycomb the wood in a most characteristic manner. At times the outer 6 or 8 in. of large trees may be completely riddled by these borings and often waterlogged as well. Chamberlin (1920), as the result of finding well-developed larvae at all seasons of the year, believes that this species requires more than one year to complete its life cycle. He also states that the larvae approach the surface before pupation, but this is characteristic of most wood-boring insects. The adults free themselves by boring directly to

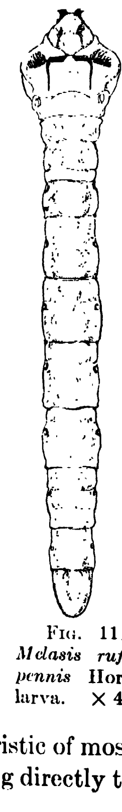

FIG. 111. *Melasis rufipennis* Horn larva. × 4.

the surface, leaving circular shot-holelike emergence holes. This species is to be found from British Columbia south to middle California, ranging east to Idaho in the North. The food trees are the Douglas and true firs, the grand fir being the preferred tree in the lowlands of Oregon, and the silver fir in the Sierras.

Melasis tsugae Hop., a slightly smaller and entirely pitchy black species, is also to be found in the Northwest. It has habits somewhat similar to those of the preceding except as to food, G. Hopping (1926) rearing his specimens from the western hemlock, *Tsuga heterophylla*, in British Columbia, while J. M. Miller has taken specimens on the Douglas fir at Ashland, Ore. The species of eastern North America is *M. pectinicornis* Melsh., which closely resembles the preceding but differs by lacking the prominent toothed ridge near the anterior prothoracic angles, so characteristic of the former. It has been reared by Charles Dury from beech near Cincinnati.

FIG. 112.—Work of *Melasis rufipennis* Horn in *Abies concolor*. Left, cross section of larval mines; right, emergence holes of adult.

The genus *Dromaeolus* is characterized by having narrow and deep antennal grooves which extend along the outer margin of the prothorax beneath and forward on to the head and by being moderately robust, elongate, cylindrical, or torpedo-shaped and well-rounded anteriorly and more or less blunt posteriorly. Our western species are four in number, on the average 8 mm. or more in length, and dark brown or black in color. Two of them breed in dead alders, *D. nitens* Horn and *D. hospitalis* Blanch., and are both black and somewhat shining, the former with the pronotum shining like the elytra, the prothoracic antennal grooves sharply defined within, and the hind coxal plates somewhat blunt at the hind angles; the second with the pronotum quite opaque, the antennal grooves not sharply defined within, and the hind coxal plates subacute at the hind angles. The other species both breed in coniferous trees, the Douglas fir or ponderosa pine. *D. basalis* Lec. is black and shining but with the basal area of elytra generally clothed with conspicuous white pile. *D. cali-*

fornicus Bon. is proportionately broader and shorter, dark brown, rufous beneath, subopaque, the pronotum densely punctured, and the elytra distinctly punctured and granular. The eastern species is much smaller and less robust than the Pacific Coast species but in general much like them and black or brown in color. The members of the genus *Fornax* closely simulate the preceding but have the antennal groove limited to the prothorax and the tarsal claws generally toothed beneath. None of these has so far been found in Western forests.

Anelastes druryi Kby., a somber brown beetle and particularly common about camps in the North and in the mountains of the Pacific Coast, averages from 10 to 12 mm. in length, is quite convex, rather blunt both in front and behind, lacks antennal grooves, and has the prosternal sutures curved and the hind coxal plates very abruptly dilated inwardly. Its complete life history is not known, though it probably lives in its early stages in old decomposing wood.

Bonvouloir, 1870; Horn, 1886; Blanchard, 1904; Van Horn, 1909; Chamberlin, 1920; Hopping, 1926; Schenkling, 1928.

FIREFLIES AND SOLDIER BEETLES

The superfamily Cantharoidea (Lampyridae) is an association of several related families formerly listed under one family name. The separate families, however, have more or less distinctive features, though the species of all agree in having somewhat soft bodies, loosely put together and with rather leathery elytra. The larvae are elongated and in many cases much like the more flattened millipedes or galleyworms in appearance. The Lycidae often have the upper surface beautifully sculptured in a reticulate manner and are frequently of pronounced colors like crimson or blue and orange. They may be found resting on the herbage or assembled about old rotting logs. The Lampyridae contain the true glowworms and fireflies, the larvae of which are generally terrestrial and to be found in damp localities. The Cantharidae are the soldier beetles, sometimes found in flowers, though often seen feeding on plant lice. They are supposedly the most useful to the forest, though the members of all of the families are predaceous to a greater or lesser degree in both the larval and the adult state. Many of the adults of *Podabrus* Westw., particularly *P. pruinosus* Lec., have been observed feeding ravenously upon the various species of aphis.

LeConte, 1881.

CHECKERED BEETLES

The family Cleridae is especially characteristic of the forests and brush lands and undoubtedly of great economic importance to both,

for the adults as well as the larvae are predaceous and feed, in the main, on timber-destroying insects, especially the Coleoptera, though lepidopterous larvae are not refused. The adults are sometimes quite antlike in appearance with large eyes, antennae with the outer segments enlarged and greatly modified, the prothorax freely movable on the afterbody, the legs strong, the body generally quite hairy and often gaily ornamented. The adults of a certain number of species frequent flowers, but most of them are to be found prowling about various trees or shrubs. Many are, in fact, quite definitely limited to certain species of plants. The larvae are elongated, wormlike, with a pair of hooks on the last abdominal segment, and of a pinkish or gray color. They prowl about beneath the bark of dead trees, enter the runways of wood-boring insects, or even burrow through the wood itself in search of their prey. The family as far as our territory is concerned is of but moderate size and with the majority of the genera small. The following are the larger or more important genera: *Cymatodera* Gray., *Thanasimus* Latr., *Enoclerus* Gahn., *Trichodes* Hbst., *Hydnocera* New., and *Chariessa* Perty.

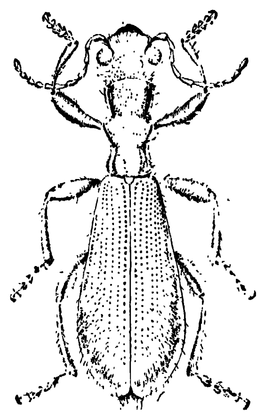

FIG. 113.—*Cymatodera ovipennis* Lec.

The genus *Cymatodera* is dominant in the more southern portions of our territory. The adults are elongate, with a narrow, cylindrical prothorax, rather long antennae, and afterbody more or less elliptical and considerably broader than the head and prothorax. Most species are brown or pitchy in color, often with lighter zigzag or nebulous markings. They are active and voracious, mostly nocturnal, and supposedly quite beneficial. In California, *Cymatodera ovipennis* Lec., a wingless species, has frequently been found by Stanley Flanders preying upon the larvae of the codling moth, *Carpocapsa pomonella* (L.), which has collected beneath the jute bands on walnut trees. In the forests most of the species are to be found about the old dead branches. The greater proportion, however, prefer the more open parts of the country like the sparsely timbered areas and brush lands of our semiarid Southwest.

The genus *Thanasimus*, though not large, contains species that are to a great extent restricted to the coniferous forests. *Thanasimus undulatus* Say and its various subspecies, which are black with transverse gray or gray and red markings, are to be found throughout the timbered areas of Alaska and Canada as well as our northern border states from Maine to Washington, the Rocky Mountains,

and the Pacific states. They frequent the spruce, fir, and Douglas fir and prey to a great extent on bark beetles. *T. repandus* Horn, a beautiful red and black species, is limited to the California redwood, *Sequoia sempervirens*, and preys upon *Phloeosinus sequoiae* Hopk. In Europe a closely related clerid *Thanasimus formicarius* (L.) is fairly common and most beneficial according to the records. Because of this fact this species was introduced into West Virginia in 1892–1893 by Hopkins (1899) for the control of the southern pine beetle, *Dendroctonus frontalis* Zimm., but it failed to establish itself. *Thanasimus dubius* Fab. is the commonest species of the genus in the eastern part of our country and generally to be found about pines.

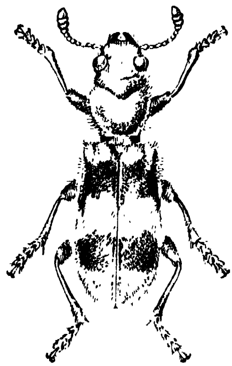

FIG. 114. *Enoclerus sphegeus* Fab. × 3.5.

The genus *Enoclerus* is one of the largest and most characteristic forest genera in our country. Many of the species are limited to coniferous trees, while others prefer the broad-leaved trees, and some few are restricted to closely related tree genera. *Enoclerus sphegeus* (Fab.), which is figured, is perhaps the commonest species in the pine forests of the West. It averages about 10 mm. in length, is of a bronze-black color with a wavy transverse bar of white across the middle of the elytra as well as a faint streak of the same near the apex and on the head, and with a bright-red abdomen. *E. moestus* (Klug.) is a bit smaller, of a black color with red abdomen, and the apical area of the elytra gray, this gray area extending forward along the suture and truncated in front. It is most frequent in the southern Sierras and Rocky Mountains and extends into Mexico. *E. lecontei* Wolc. (*Thanasimus nigriventris* Lec.) is also a common species in the western pine forests. It is considerably smaller than either of the preceding, black with a black abdomen, the elytra gray at the apex, and with a poorly defined transverse gray band in front of the middle and somewhat gray back of the scutellum. This species has been found by H. L. Person (1928) to be one of the most important predators on the western pine bark beetle, *Dendroctonus brevicomis* Lec., and to exert a considerable influence in keeping it under control. A species of similar size and coloration, except that the humeral angles are red,

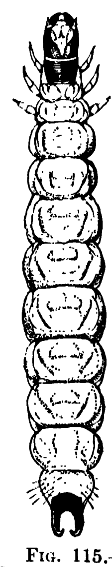

FIG. 115.—*Enoclerus sphegeus* Fab. larva. × 3.5.

is *Enoclerus humeralis* Schffr., which ranges throughout the same territory but is much less frequent and more apt to be found about the smaller branches or infested cones. *E. cupressi* Van Dyke, a robust, bluish-black species with red humeral spot and transverse bands at the middle of each elytron, not reaching the suture but united along the lateral margins with the humeral spots, and red abdomen, has been found restricted to the Monterey and Sargent cypresses of California. This species preys upon *Phloeosinus cupressi* Hopk. and probably also the larvae of the cypress cone moth, *Laspeyresia cupressana* Kearf., and one of the death watches, *Ernobius cupressi* Van Dyke. *Enoclerus eximius* Mann., a beautiful black species with orange abdomen and orange-red elytra except for a subhumeral and post-scutellar black markings, often united, and black apices, and more or less clothed with gray pile over the black areas, is a fairly common species in various parts of the Pacific slope. It is most often found about willows, alders, California laurel, and other stream-side plants and lives mainly at the expense of various Anobiidae such as *Hadrobregmus gibbicollis* (Lec.) and *Ptilinus basalis* Lec.

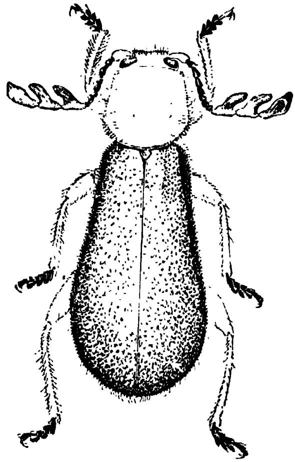

FIG. 116. *Chariessa elegans* Horn. × 7.

Among the other Cleridae which might be mentioned are *Trichodes* Hbst. which in the adult state are pollen feeders and, in the larval, parasitic in the nests of bees. The well-known black-and-yellow barred *Trichodes ornatus* Say of the west is commonly to be found tucked away in the heads of various flowers. The genus *Hydnocera* Newn. contains a large number of small, antlike beetles which are, in the main, gray or marked with yellow and generally quite hairy. They are most abundant in our Southwest where they are generally to be found running over the branches of various trees and shrubs. *Chariessa* Perty. of the subfamily Corynetinae contains but four species in our territory, yet one of these, *Chariessa elegans* Horn, is a rather important predator in Oregon, California and Arizona. It is over 6 mm. in length, robust, and with elytra a beautiful blue color and legs and other parts a rich orange-red. It frequents the madrone and white oaks and preys upon the larvae of various Cerambycidae like *Neoclytus conjunctus* Lec., which breed in such trees.

Horn, 1876; Hopkins, 1899; Schenkling, 1903, 1910; Van Dyke, 1923; Person, 1928.

The small and anomalous family Othniidae (Elacatidae) is now placed close to Cleridae. There is but one genus in this country, *Othnius*, and only four recorded species. The best known of these is *Othnius lugubris* Horn, a beetle that somewhat suggests one of the more elongate *Hydnocera*. It is rather small and elongated, black with indistinct gray markings, and is at times abundant about dead ponderosa pines in the forests of the Pacific Coast. Its habits are, as far as known, similar to those of the Cleridae.

Horn, 1871; Borchman, 1910.

THE POWDER-POST BEETLES

The superfamily Ptinoidea contains four more or less closely related families, the Ptinidae, Anobiidae, Bostrichidae, and Lyctidae, the members of which all breed in old dry wood or dead and dry vegetable products. The adults may be short and chunky or somewhat elongate and cylindrical. The larvae of all are quite similar, grublike, the head of fair size and with powerful jaws, the thoracic segments enlarged and each provided with a pair of well-developed legs, and the abdomen narrowing and more or less coiled. These larvae simulate closely the so-called white grubs, the larvae of the Scarabaeidae, though differ in having the anterior portion of the body the larger, giving them a bull-like appearance, whereas the apical portion of white grubs is often much the larger portion. These insects also live generation after generation in the same material, ultimately completely honeycombing it and reducing much of it to a condition of fine powder; hence the common name. They are all vegetable scavengers, those in the virgin forests most useful in that they assist in doing away with old, useless woody materials but most destructive from our viewpoint when they attack the lumber and woody materials which we are using.

THE PTINIDS

The beetles in the family Ptinidae are small with long, filiform antennae inserted on the front of small heads, the prothorax also small, and the afterbody more or less spherical. With their long legs they thus look much like spiders. Many of them are destructive to household articles like dried herbs, vegetable drugs, or foods, while others breed in old straw. Most of our native species are to be found breeding in old grass roots or in the bark or dead twigs of trees so as far as the forester or lumberman is concerned are of little economic importance.

Fall, 1905: Pic, 1912.

THE DEATH WATCHES

The members of the family Anobiidae are usually more or less cylindrical and either short and compact or slightly elongate, with the antennae inserted laterally near the eyes and the outer segments of the antennae more or less enlarged or greatly elongated, and the tibiae without spurs. They all breed in old dry wood, many of the forest species confining their attention to twigs, while others attack the larger limbs or main trunk. Many of these have adapted themselves to man's habitations and have attacked the finished timber products

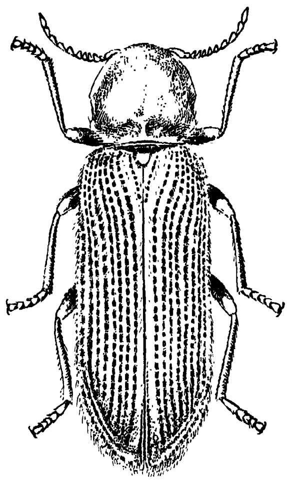

FIG. 117.—*Trypopitys punctatus* Lec. × 10.

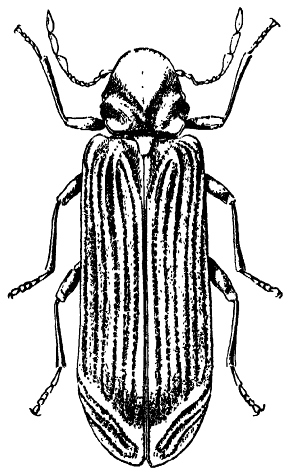

FIG. 118.—*Hadrobregmus gibbicollis* Lec. × 10.

such as the girders, beams, and supports of old houses or even the wood ornaments or furniture within them. They have thus become of great concern to man. Several of the species have proved to be tremendously destructive. In Europe the most commonly found species are the furniture beetle, *Anobium punctatum* DeG., and the death watch, *Xestobium rufovillosum* (DeG.), the first a cylindrical brown beetle, 4 to 6 mm. in length, with pronounced punctate striae; the second somewhat larger (7 mm. in length) and proportionately broader than the preceding, of a reddish or dark-brown color somewhat obscured by a covering of short, yellow-gray pile. Because of the fact that both of these beetles attack old furniture they have been introduced into this country from time to time by collectors of antiques. We also have many native species, but fortunately most of these confine their attention to the dead and useless timber in the forest. A few, however, have proved to be quite troublesome to householders.

In southern California, *Trypopitys punctatus* Lec., a species that looks superficially much like the Old World furniture beetle, has been found attacking oak door casings and floorings as well as maple wainscotings. This species also, according to Burke, breeds in Monterey cypress and pine. In the San Francisco Bay region, *Hadrobregmus gibbicollis* (Lec.), a slightly narrower insect, has been found vigorously attacking beams of Douglas fir in old bridges and barns as well as the basement timbers of residences, especially where age or moisture has somewhat changed the texture of the wood. The California laurel, *Umbellularia californica*, has a wood that is very beautiful and in many ways well-suited to interior finishings but has had to be abandoned to a great extent because while being cured it is so readily attacked by *Ptilinus basalis* Lec., one of the members of this family, as well as by *Scobicia declivis* (Lec.), one of the Bostrichidae. In the woods young pine plantations also suffer somewhat from other members of the family, chiefly of the genus *Ernobius*, the commonest species of which is *Ernobius punctulatus* (Lec.). These beetles will attack and kill weakened shoots of young trees. They are most abundant where dead branches have been allowed to accumulate in the neighborhood.

FIG. 119.—Work of *Hadrobregmus gibbicollis* (Lec.).

Pic, 1912; Gahan, 1920*a*; Blake, 1925; Girwood, 1927.

THE BOSTRICHIDS

The members of the family Bostrichidae are most abundant in the warmer parts of the world. They are also larger on the average than are the species of the other related families, such, for instance, as *Dinapate wrighti* Horn, found on the native fan palm of the deserts of southern California, being well over 25 mm. length. The distinguishing characters of the family are that the antennae are inserted before the eyes, the tibiae have distinct spurs, and the first ventral segment is scarcely longer than those that follow. Otherwise, they are much like the Anobiidae and quite similar as regards their biology. Several of our species are of special interest.

Scobicia declivis (Lec.) is a cylindrical species of a reddish-brown color, 5 to 6 mm. in length, with the head tufted in front, the pronotum granulate and with a limited number of sharp tubercles in front, the elytra with rather deep punctures arranged more or less in rows, and the apical declivity with a pair of closely placed sharp spines at its apex and with a rather deep, smooth sulcus on either side of the suture. It is quite common in southern Oregon and California and breeds freely in the dead timber of many kinds of trees, foreign as well as native, such as the acacia, eucalyptus, oak, manzanita, madrone, and California laurel. The females burrow deeply into the sapwood and there lay their eggs, the larvae later tunneling the wood in a most thorough manner. The softer woods are completely honeycombed. This beetle is greatly stimulated by heat so during the warm days of late spring and early summer may appear in great numbers. Then they may not only swarm about dwellings, particularly if they have been newly painted or a fire has started in the neighborhood, but fly to the heavy lead cables carrying the telephone and telegraph wires. The odor of lead seems to attract them, so that they fly to the cables and, wherever they can get a purchase, bore through into the inner lining. In consequence, short-circuiting may take place when the cables become damp. Because of this habit the beetle has become known as the "lead cable borer" and as such has won quite a reputation among electrical workers. Losses of power through its activities have been great, and much experimental and field work has been done in order to devise methods for suspending the cables in such ways as to minimize the work.

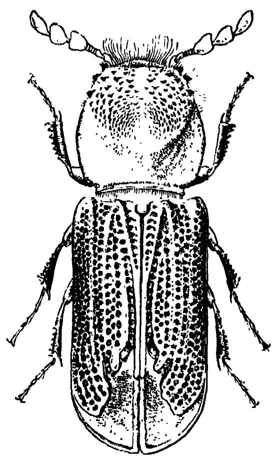

FIG. 120. *Scobicia declivis* (Lec.). × 10.

Amphicerus cornutus (Pallas) is reddish brown in color and glabrous like the preceding but much longer, 6 mm. or more in length. It has two small, hooked horns on the anterior margin of the pronotum as well as a series of sharp tubercles generously scattered over the anterior face of the pronotum, while the elytra are rather coarsely and serially punctured. It breeds freely in dead mesquite and related trees in our Southwest and in consequence often renders the wood of these trees unfit for commercial uses. It is also quite common in western Mexico and has been introduced into the Hawaiian Islands. Other closely related species both in the Old as well as the New World are accountable for much injury to valuable hardwoods and dyewoods.

Dinapate wrighti Horn, the giant of the family, may reach a length of from 38 to 47 mm. It is of a reddish-brown color, more or less glabrous above and hairy beneath, and in general except for its size looks much like the preceding. It breeds in the old dead trunks of the California fan palm, *Washingtonia filifera,* throughout the area where this tree grows as a native on the north and western margins of the Colorado desert in California. In recent years this beetle has been observed attacking and seriously injuring many growing trees, particularly such as had been transplanted and were therefore not

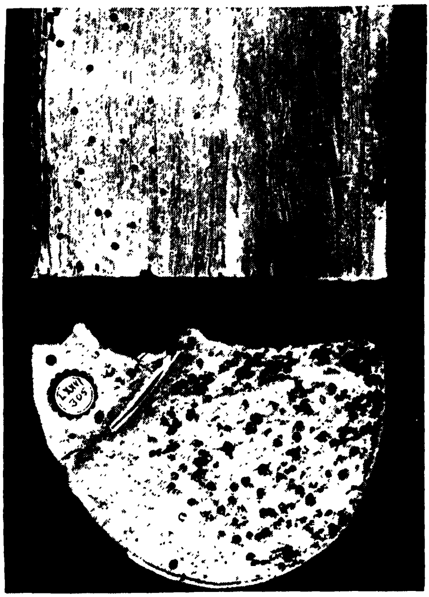

FIG. 121. - Work of *Scobicia declivis* (Lec.) in fig wood. Upper figure shows emergence holes of adult, lower figure the larval burrows.

in a thriving condition. In their native environment growing trees are not generally attacked.

The genus *Polycaon* Lap. with *Heterarthron* Guer., which may be considered as but a subgenus of the first, contains about nineteen species confined to western North America and South America. They all breed in dead wood, and several are of considerable economic importance. *Polycaon stouti* (Lec.), a cylindrical, coal-black species with broad head, 1.5 to 2 cm. in length, is our largest California species. It may attack almost any of our softwood deciduous trees as well as several of the hardwoods. In southern California there is at one of the mountain resorts a large dining hall built many years ago out of hewn alder logs. The beetles have thoroughly established themselves in the timbers of this building and as a result of their borings

year after year have so greatly weakened the structure that it will soon have to be replaced. In middle as well as southern California, they have also done considerable damage to curing eucalyptus logs. It is, however, in the storage warehouses of the hardwood lumber companies that some of the most serious injury has been observed. The custom of many furniture factories is to use what is called a three-ply panel for making desks and similar articles. The inner portion of the panel is a softwood like basswood, and the outer a

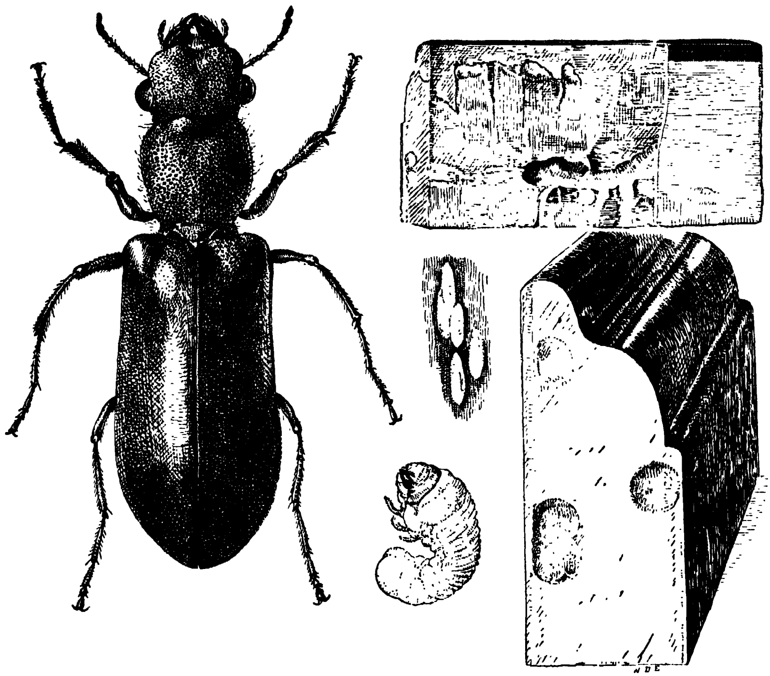

FIG. 122.—*Polycaon stouti* (Lec.). Adult × 4; larva and egg × 2½; work in molding × 1. (*Edmonston.*)

hardwood like oak or mahogany. The night-flying beetles gain access to these more or less open warehouses and establish numerous colonies of larvae in the stacked panels. These work in the inner panel so that their presence does not become known until after the panels have been made into furniture, when the larvae having reached maturity and transformed into adult beetles bore directly out through the veneer. Many handsome desks and other furniture have been injured in this manner. *Polycaon confertus* Lec. is a much smaller species, about half the size of *P. stouti*, and of a reddish-brown color. It breeds commonly in many types of dead trees such as acacias, the

grape, and most orchard trees. It does its greatest damage through working backward from stubs or pruned branches toward the living tissues, causing the plants gradually to die back and thus producing much distortion. It may also do some damage in the adult state by nibbling out short burrows at the axils of the small branches in growing trees. These are supposed to be for feeding purposes or for a retreat and are most often found when piles of prunings have been allowed to remain in the neighborhood of the orchards.

Dinoderus minutus Fab. is one of the smaller species of the family and is much like a bark beetle in appearance. It is cylindrical, brown in color, and 3 to 4 mm. in length. It is a native of the Orient—China, Japan, and India—and breeds in great numbers in the inner portion of bamboo, which is in consequence rendered worthless. Much of the bamboo brought into this country in the form of bamboo furniture, ornaments, or poles has been found to be infested with this insect.

Psoa quadrisignata (Horn) is a very pretty borer, variable in color, generally blue with red shoulders or with an additional red patch near the apex of the elytra or red with blue markings, and averages 10 to 12 mm. in length. It breeds most frequently in oak twigs that have recently been killed. In early spring in California it generally can be beaten from the oak branches that have been killed by the previous winter's storms.

Horn, 1878, 1886*a*; Lesne, 1895–1909; Burke, Hartman and Snyder, 1922; Hubbard, 1899; Martin, 1917; Garnett, 1918.

THE TRUE POWDER-POST BEETLES

The members of the family Lyctidae are the most typical of the powder-post beetles, and the common name is by many restricted to them. It is a small family with the typical genus *Lyctus* Fab. the most important. The beetles are small, from 2 to 5 mm. in length, more or less cylindrical though a bit flattened, black or brown in color, with rather short antennae inserted before the eyes, and with a terminal club, the tibiae with distinct spurs, and the first ventral segment very much elongated. In nature these beetles breed in old, well-cured wood as in the dead branches of trees, but many of them have now become well-established in hardwood warehouses and buildings. They gain access to the wood while it is being cured or stored and inasmuch as they work below the surface may not make their presence known until long after the wood has been fashioned into tools, wagon parts, furniture, household ornaments, or installed as floors or other interior finishings. When, as larvae, they have thoroughly eaten out the interior and reduced it to a condition of fine powder, the insects transform to adults and bore their way through

to liberty, leaving their shot-like exit holes as the first visible signs of their presence. Thus, they not only mar and render the woodwork unsightly but through continued borings generation after generation leave but the merest shell to the wood, with the result that it sooner or later gives way completely. In the case of furniture, tools, wagons, or places where the wood has been used for supporting purposes, as girders in buildings or in shipbuilding, serious accidents may occur. The preferred woods sought by these beetles are oak, ash, hickory, maple, and, in the Orient, bamboo. The commonest species to be met with in this country are *Lyctus brunneus* (Steph.), a well-known European species introduced by commerce into the eastern United States and well-known in Japan whence it has been carried in bamboo to the Pacific states of North America and most likely to the Hawaiian Islands, for it is now well-established in both places; *L. linearis* (Goeze), another common European species which has become established in the hardwood storehouses in the Eastern part of the country and is there doing considerable damage; *L. planicollis* Lec., a native species most common in the southern states but ranging west into Arizona, Nevada, and California and very destructive at times to ash, hickory, and oak; and *L. cavicollis* Lec., the commonest native California species which breeds freely in oak cordwood but has also begun to establish itself in the hardwood warehouses as well as in private homes. *L. brunneus* (Steph.) is distinguished by being reddish brown in color, the prothorax wider than long and wider in front of the middle, and with the pubescence rather evenly distributed over the entire surface; *L. linearis*, likewise brown but with the prothorax almost square and distinctly narrower than the elytra and with a deep, elongate, discal impression and the elytral striae punctured with a single row of large, shallow, circular punctures; *L. cavicollis* somewhat similar to the preceding but with the striae punctures in a double row and the anterior portion of the prothorax narrower than the elytra at base; while *L. planicollis* is black in color with the prothorax broader anteriorly than the base of the elytra and with a shallow, discal impression, otherwise moderately like *L. cavicollis*.

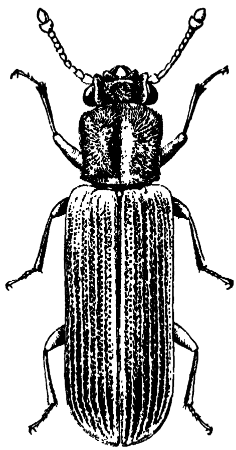

FIG. 123.—*Lyctus cavicollis* Lec. × 10.

The best method of preventing losses from any of the foregoing types of powder-post beetles is by exercising care in the handling of the wood. Use only heartwood where possible, cure away from

contaminated materials, inspect the stock frequently, remove all lumber showing evidences of attack, burn all useless sapwood and trash, and dispose of older stock as rapidly as possible. Material may be protected against attack by thoroughly treating with linseed oil or coal-tar creosote and to a certain extent by long submergence in water or steaming under pressure. When slight infestation has taken place the larvae may be killed by liberally treating the wood with kerosene, orthodichlorobenzene, creosote, or, in the case of small, valuable articles, by soaking with turpentine or a 10 per cent solution of kerosene in turpentine. Kiln drying at a temperature of 180°F. or steaming with a saturated atmosphere for one and a half hours at a temperature of 135°F. may also be of value. In large timbers the infested area, which is generally the portion containing the sapwood, if superficial, may be stripped off and destroyed. Small articles like pieces of furniture may also be fumigated with hydrocyanic acid gas by being placed in steel chambers and having a partial vacuum produced before the gas is admitted. Where the wood is badly infested it should be removed and destroyed by burning.

FIG. 124.– Work of *Lyctus cavicollis* Lec. showing typical work of a powder post beetle in oak flooring. Left, showing adult emergence holes; right, top of board removed showing work of larvae.

Knaus and Hopkins, 1911; Hopkins and Snyder, 1917; Snyder, 1926.

THE DARKLING BEETLES

The family Tenebrionidae is not only the largest family of Heteromera or those beetles that have the tarsal formula of 5-5-4, but it is the one that contains the most diverse types. The majority of the species are of somber hue, but few species and those chiefly found in the tropics being metallic or ornamented with bright colors. Practically all are nocturnal, and all are vegetable feeding, living primarily in old rotting wood, fungi, or the decomposing material to be found in the soil. In the main, they are scavengers. Considerable numbers are to be found throughout the forested areas of the world, chiefly within the tropics, and among these are the more generalized forms with fully developed wings. The great majority of the species are,

however, restricted to the hot and more arid regions of the world, where they form one of the more characteristic components of the insect fauna. In the North American forests, particularly those of the West, are to be found quite a number of species, and as many of these are quite evident even though not very destructive, the more conspicuous ones will be mentioned.

The tribe Nosodermini of the subfamily Tentyriinae contains several genera of rather large, somewhat flattened, elongate, roughly sculptured, and somber beetles which are always to be found about decaying logs or stumps or the large, woody bracket fungi. *Phloeodes diabolicus* Lec. of middle California and *P. postulosus* Lec. of southern California, both with a cordate prothorax and a double series of three velvety-black patches on the disk of the elytra, and the former in addition with patches of white scales at the humeri and near the apex, are to be found commonly about the stumps of decaying willow, oak, sycamore, or similar trees. *Noserus plicatus* Lec., a smaller yet somewhat similar insect, entirely of a rusty-brown color, with four prominent subapical tubercles and much resembling a chip of bark, is to be found in California wherever there are dead live oaks. *Phellopsis obcordata* (Kby.) and *P. porcata* (Lec.), both with large elytral punctures arranged in rows and with several of the elytral intervals more or less elevated, are to be found in our coniferous forests, the adults often feeding upon the large bracket fungi. The first-mentioned species ranges through the forests from the New England states to the Rocky Mountains and throughout much of Canada and Alaska, while the second is confined to the Pacific Coast.

In the two small subfamilies Bolitophaginae and Diaperinae are to be found a number of genera and species which breed in the main in the larger woody and chalky fungi, *Trametes*, *Fomes*, and *Polyporus*, of the forests. In the first subfamily the beetles are short compact, and roughly sculptured. The common *Bolitotherus cornutus* (Panz.), ornamented with a pair of prominent prothoracic horns in the male, is widely distributed throughout eastern North America. In California its place is taken by a somewhat smaller, hornless relative, *Megeleatus sequoiarum* Csy., found abundantly at times in the broken-down chalky fungi on white fir. *Eleates* with still smaller and less convex species is represented in the Northeast by *E. depressus* (Rand.) and on the Pacific Coast by *E. occidentalis* Csy. In the second subfamily we have a number of genera with small, smooth, and somewhat hemispherical species. *Diaperis maculata* Oliv. of the East with its orange and black markings looks not unlike a robust lady beetle. In the West there are other species, but they are uncommon. The genus *Platydema* C. & B. contains small, elliptical, gener-

ally black, and very active beetles, the only Pacific Coast species, *P. oregonense* Lec., being found in numbers in both coniferous and oak forests. In the eastern part of the country there are many species, but all have somewhat similar habits, that of feeding on various tree fungi.

The members of the subfamily Ulominae are elongate, more or less cylindrical, and quite smooth. The typical genus *Uloma* Cast. has one representative in western North America, *U. longula* Lec., a reddish species about 10 mm. in length. This breeds in old, decomposing coniferous logs. In the East and South numerous species having somewhat similar habits are to be found. The genus *Corticeus* Piller. (*Hypophloeus* Fab.), more or less world-wide in its distribution, contains a number of North American species. These are small, more or less cylindrical, reddish-brown or black beetles, which are often to be found in the runways of various bark or wood-boring beetles. They were generally believed to be somewhat predaceous but have been proved by G. R. Struble (1930) to be nothing more than scavengers. The commonest species of the eastern part of the country is *C. parallelus* (Melsh.), found in coniferous trees; and of the Pacific Coast, *C. substriatus* (Lec.)

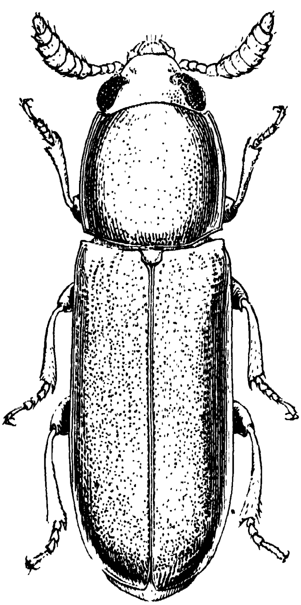

FIG. 125. *Corticeus substriatus* (Lec.).

In the large subfamily Tenebrioninae are to be found many of our largest forest species. These also play a not unimportant role in the forest, for they materially assist in finally disposing of the old dead and rotting timber. *Conotrophus parallelus* (Lec.) is a large black beetle, 20 mm. in length, elongated, slightly convex, with sides quite parallel, the pronotum finely punctured, and the elytra with series of well-defined elongate punctures as well as somewhat rugose. It is common in California in old decaying coniferous trees. *Cibdelis blaschkei* Mann. is a dull-black species, 15 to 20 mm. in length, with both prothorax and elytra well-rounded on the sides, the upper surface very convex, the elytra rough and with series of small, shining tubercles laterally, and the tarsi densely clothed beneath with golden pile. It is very common throughout middle California, breeding

in old dead oaks. The genus *Coelocnemis* Mann. contains the largest species of the family found in our forests with species in California, Arizona, Nevada, and Utah. They all breed in rotting timber, most commonly oak. They are very robust with the prothorax generally well-dilated and convex, the elytra somewhat cordate as well as convex, the legs long, and the tarsi clothed with golden pubescence as in *Cibdelis* Mann. They superficially resemble some of the larger *Eleodes* Esch., the most characteristic tenebrionids in western America, but can always be readily separated by their silky tarsi and habits of

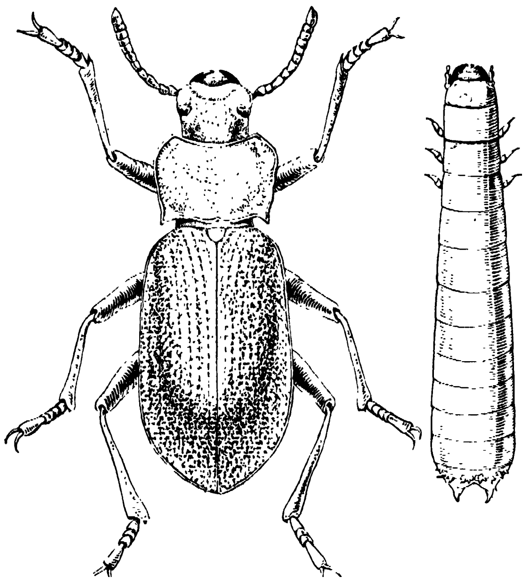

FIG. 126.—*Iphthimus serratus* (Mann.), × 2.5, and larva, × 2.

remaining close to dead timber. The genus *Iphthimus* Tru., one of the species of which is figured, is one of the most typical of our northern forest Tenebrionidae. The species are large, more or less elongated, and somewhat flattened. The common *Iphthimus serratus* (Mann.) of the Pacific Northwest is a very rugose species, about 25 mm. in length. The more southern subspecies, *I. sublaevis* Bland, from the Rocky Mountains and California is somewhat larger and less coarsely punctured, while the extreme phases, the subspecies *lewisi* Horn from New Mexico and *laevissimus* Csy. from the mountains of southern California are quite smooth. Most old, rotting coniferous logs will be found to have numerous specimens of these beetles about them, and a dissection of the logs will yield many of the large, cylindrical, yellowish-brown larvae. *Alobates* (*Nyctobates*) *pennsylvanica*

(DeG.) is found from the Atlantic to the Pacific. It is rather narrow and much elongated, 20 mm. long, black, rather loosely put together, with prothorax but little wider than long and elytra somewhat wider and about three times as long as broad, the tarsi with golden pubescence beneath. It is very common beneath the bark of dead hardwoods throughout eastern North America and less common on the Pacific Coast. *Upis ceramboides* (L.) is another elongated and loosely put together species. It is smaller than the preceding and has the elytra very much pitted. Its range is throughout the boreal parts of the Old as well as the New World, being very common in the region from the Yukon Valley to the Great Lakes.

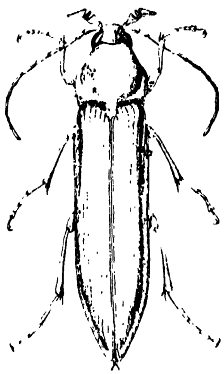

FIG. 127. *Serropalpus barbatus* (Schall.). × 3.

In the subfamily Helopinae the most important genus is *Helops*. It is found throughout the Northern Hemisphere and in North America has many representatives, some of which are closely associated with dead timber of all types. They are all rather loosely put together, generally somewhat elliptical and quite convex, some somber in appearance, black or brown in color, while others are brilliantly metallic. Many of the smaller species are confused with certain Carabidae by beginners, but the tarsal formula will always readily separate them.

Horn, 1870; Casey, 1907; Gebien, 1910; Struble, 1930; Blaisdell, 1909, 1921.

THE MELANDRYIDS

The family Melandryidae is a rather small one, but practically all of the species are to be found in the forest where they breed in the old dead and rotting timber or in the various types of fungi which develop on them. They may be elongate and cylindrical or somewhat elliptical, generally somber in color though often prettily variegated and always active, several of the species having saltatorial powers. The distinctive characters separating them from the Tenebrionidae and other Heteromera are that the anterior coxal cavities are open behind, the head gradually narrowed back of the eyes, the middle coxae not especially prominent, and the pronotum margined at the sides and with evident though often shallow basal impressions. Some few of the species are quite common, often seen running over the surface of dead trees or tucked away in cracks and beneath the bark. *Xylita laevigata* (Hellw.), a brown or yellowish-brown insect, about 7 mm. in length, and somewhat simulating an elaterid or snapping beetle in shape and actions, is found throughout the coniferous forests

of the Northern Hemisphere. It is often seen in numbers running up and down tree trunks, particularly the fire-killed trees. *Serropalpus barbatus* (Schall.), a reddish-brown species of similar distribution, but much larger (12 to 20 mm. in length) and considerably attenuated at both ends, is a most active insect. It is often attracted in numbers to camps.

Horn, 1888*b*; Blair, 1928.

THE PYTHIDS

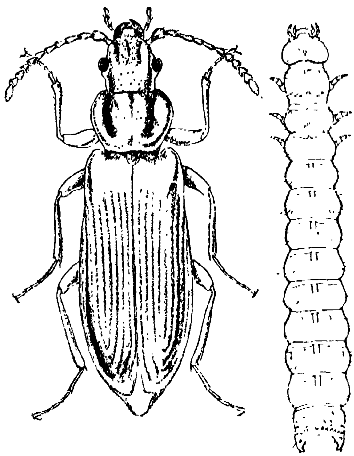

FIG. 128.—*Pytho planus* Hbst. and larva. × 3.5.

The family Pythidae is also small and quite closely related to the preceding, differing by having no lateral thoracic margins and basal thoracic impressions. Our largest species is *Lecontia discicollis* (Lec.), a rather long, somewhat flattened beetle with moniliform antennae. It is quite often found beneath the bark of dead coniferous trees in the territory from the Great Lakes to the Cascade Mountains. The typical genus *Pytho* Latr. is also northern in distribution. Both larvae and adults are to be found beneath the bark of dead coniferous trees. The former are elongated, flattened insects as shown in the figure and much resemble the larvae of the typical genus *Cucujus* Fabr. of the Cucujidae and *Dendroides* Latr. of the Pyrochroidea. The adults are 15 mm. or more in length, with somewhat parallel sides, flattened, with the pronotum broadly impressed on either side of the middle, and the elytra deeply striate. *Pytho americanus* Kby. and *P. deplanatus* Mann., now generally placed as but phases of the European *P. planus* Hbst., may be either piceous or rufous and generally with a pronounced bluish luster. The first is found throughout the boreal parts of eastern North America, and *P. deplanatus* in Alaska and the Pacific Northwest. *P. niger* Kby., a smaller black species is restricted to northeastern America; and *P. strictus* Lec., to the Atlantic seaboard. *Priognathus monilicornis* (Rand.), a rather small beetle (rarely more than 6 or 8 mm. in length), is quite cylindrical, of a shining brown or piceous color, and generally to be found in rotting logs throughout the coniferous forests of the Pacific Coast and from Maine to Washington. The members of other forest genera like *Salpingus* and *Cariderus* (*Rhinosimus*) are very small, shining, somewhat greenish or bronzed beetles, the latter with a

pronounced snout. They are twig feeding, therefore of less interest to the general forester.

Horn, 1888*b*; Blair, 1928.

THE OEDEMERIDS

The Oedemeridae are, in general, narrow, elongate, soft-bodied beetles of black, bluish, or more often gray or light-brown color. The adults may be found in flowers or about old wood, often near watercourses or the seashore. Most species are either crepuscular or nocturnal, therefore are frequently attracted to lights. The early stages are passed in old wood, some species preferring that which is somewhat damp or soggy, others that which is well dried out. The distinctive features of the adults other than the tarsal formula of 5-5-4, characteristic of all the Heteromera, are that the anterior coxal cavities are open behind, the head not suddenly constricted behind, the middle coxae prominent, and the lateral suture of prothorax wanting.

The number of species in America is not large, but several are worthy of being mentioned because they often come under the observation of the forest entomologist. *Calophus angustus* Lec. is a very long brown species, 12 mm. or more in length, which breeds in old timber of various species of conifers such as pine, fir, and cedar and is to be found throughout our northern forests from Maine to Washington as well as in the Rocky Mountains, Cascade-Sierra Nevada ranges, and western Canada. *Nacerda melanura* (L.) is a yellow beetle with black apices to the elytra, sometimes all dark, and from 7 to 8 mm. in length, which has been carried by commerce from Europe to this country. It is now frequently found along the Atlantic seaboard, about the Great Lakes, and on the Pacific Coast, especially about the port of San Francisco. It breeds in old wharves, old wooden hulks, and similar places. The genus *Ditylus* has three species in North America, the commonest being *Ditylus quadricollis* Lec., a somewhat robust, black or brown beetle, over 25 mm. in length and found along the Pacific Coast from Alaska to middle California. It very closely simulates a longicorn beetle in appearance and haunts our mountain watercourses, the adults being generally found concealed about old bridges or driftwood, especially such as is somewhat waterlogged. *Copidita quadrimaculata* (Mots.), is a long, light-brown species with four black spots on the pronotum. It is to be found about the old driftwood well back from the normal high watermark along our California coast. It has apparently not yet established itself about our wharves as has *Nacerda*. *C. bicolor* (Horn), a somewhat smaller

species, a brownish-yellow color with slate-colored elytra, has, however, developed habits that have made it a species of some economic importance. It has been found breeding in the old mine timbers deep down in the mines of Amador County, California, as well as in old rotting bridge timbers.

Horn, 1896; Burke, 1906; Schenkling, 1915; Hippisley, 1922.

THE MORDELLIDS

The family Mordellidae contains a large number of species, most of them of small size and generally to be found in the adult state about flowers. These are convex, laterally compressed beetles which have decided saltatorial powers, so jump about like fleas when disturbed. They live as larvae in twigs, the few larger species probably in the main trunks of dead trees, as they are generally to be found about them. Some of the larvae are undoubtedly phytophagous; others supposedly predaceous, at least at times. So far none have been found to do any great amount of harm.

Smith, 1882; Csiki, 1915.

THE PYROCHROIDS

The family Pyrochroidae is a small one though containing insects mostly of fair size, 10 mm. or more in length. The adults have a small head and prothorax, the female with serrate, the males with flabellate, antennae and rather flattened afterbodies. They are somewhat loosely put together and may be entirely light brown, red, and black or even crimson in color. The larvae are to be found beneath the bark of dead and decomposing softwood trees like the alder or poplar. They are much elongated and flattened, with a pair of hooks on the anal extremities, giving them much the appearance of the larvae of *Cucujus* Fabr. as well as of several other coleopterous larvae found in similar situations. They are merely wood scavengers and as such of little direct economic importance. *Dendroides ephemeroides* (Mann.) is a western species.

Horn, 1888*a*; Blair, 1914, 1928*a*.

THE BLISTER BEETLES

The large family Meloidae contains beetles of moderate or even large size. They are dominant in the warmer parts of the world. Their larvae feed on the eggs and stored pollen of bees or on the egg masses of grasshoppers. The adult beetles, however, are vegetable feeding, sometimes appearing in great numbers and doing considerable

damage through defoliation. In this country most of the injury is done by members of the genus *Epicauta* Redt., *Macrobasis* Lec., or *Lytta* Fab. These are generally black, brown, gray, or metallic green in color and 12 mm. or more in length. In the Old World the greatest amount of injury is done by the species of *Zonabris* (*Mylabris*), large black beetles with the elytra more or less ornamented with orange or red markings. These beetles are most harmful to young trees, many a new plantation or nursery plot being badly stripped of leaves within a short time.

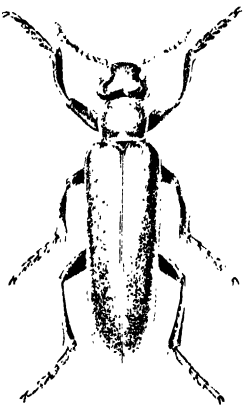

FIG. 129. *Lytta insperata* Horn. × 1.75.

LeConte, 1853; Horn, 1873*a*; 1885; Fall, 1901; Wellman, 1910; Borchmann, 1917; Van Dyke, 1928.

MAY BEETLES AND JUNE BEETLES

The family Scarabaeidae is a large family of beetles the majority of species of which are truly phytophagous in both the larval and the adult state, though few do much damage to our forests. The root-feeding larvae, the so-called white grubs, are often very destructive to nursery stock or to the young trees in the plantations or forest. Those species which live in old rotting stumps or roots may sometimes invade the growing tissues and so weaken the tree. It is the adults, however, which generally do the greatest amount of damage, and this as a result of their leaf-feeding habits. These sometimes appear in great numbers and do considerable defoliation. The European cockchafer, *Melolontha vulgaris* L., is notorious in this regard, appearing periodically in very great numbers and doing much damage. In other parts of the world, certain species are equally destructive.

In the subfamily Melolonthinae are several genera whose species are of economic importance to the forest. Such are some of the species of *Serica* Mach., as *S. fimbriata* Lec., *S. mixta* Lec., *S. alternata* Lec., and *S. anthracina* Lec., all of which feed in the adult state on the foliage of manzanita and other native shrubs. When this native growth has been removed and the land used for forest or orchard purposes, the young trees are apt to be severely attacked for a number of years. *Diplotaxis* has similar habits but so far has not been accused of doing quite as much harm. *Phyllophaga* Har. (*Lachnosterna* Hope), a large genus containing many species of good size in the eastern part of the country but with few representatives in the West, has been very destructive at times to grasslands and farm crops through the work of the larvae, and some defoliation has been attributed to

the adults. The larvae of *P. fusca* (Froel.) are sometimes destructive to the roots of young conifers throughout the East. *Polyphylla* Har., a related genus whose species are, in the main, brown and white striped, is more evident in the western part of the country. *P. decemlineata* (Say) is common in the Rocky Mountain region and throughout the Southwest including southern California; *P. crinita* Lec., a species also of large size but with considerable hair on its pronotum, is more or less limited to the northern coast counties of California, while *P. sobrina* Csy., a smaller and more reddish species, is dominant throughout the mid-Sierra region. The larvae live mainly in very sandy soils such as the seacoast sand dunes and the sandy bottom lands bordering our streams. The adults have been observed feeding on pine needles. *Thyce* Lec., containing rather large species of somewhat uniform coloration, has many species in middle and southern California. The adults of these generally feed upon the oaks, though they will attack fruit trees.

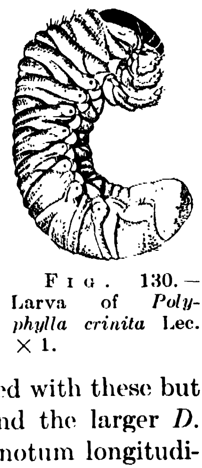

FIG. 130.—Larva of *Polyphylla crinita* Lec. × 1.

The genus *Dichelonyx* Har. is one of the most typical of the forest genera of Scarabaeidae in the more northern parts of North America. The adults of all species are to be found about trees or shrubs. The common species of the Cascade Mountains is *Dichelonyx fulgida* Lec., a reddish-brown or brown beetle with brilliant-green elytra and about 10 mm. in length. In the Sierra Nevada Mountains, its place is taken by *D. crotchi* Horn, a close relative. Associated with these but generally at slightly higher elevations is to be found the larger *D. vicina* Fall. This species differs in having the pronotum longitudinally sulcate. The closely related *D. valida* Lec. replaces this along the coastal areas of northern California, while *D. sulcata* Lec. ranges throughout the Rocky Mountains, and *D. albicollis* Burm. is to be found in northeastern America. These species with green elytra are always more or less associated with coniferous trees, especially the firs, upon the needles of which they feed, though it cannot be observed that they ever do much damage. Of other species, we have in *D. decolorata* Fall a reddish one with sulcate pronotum and black and straw-colored elytra, found commonly on the Monterey pine at Monterey, Calif.; and *D. lateralis* Fall, a larger but somewhat similar colored species distributed along the western flanks of the mid-Sierran region and generally to be found about pines and firs. In the Yosemite Valley, we also have in *D. vandykei* Saylor a more or less golden-yellow species with nonsulcate pronotum, which prefers the foliage of the mountain live oak, *Quercus chrysolepis*, and

which so closely harmonizes with the downy yellow tomentum of the underside of the leaves that it is not readily seen.

Within the subfamily Rutelinae, the larvae of which are root feeders, are many genera and numerous species which are greedy feeders on foliage during the adult stage. Fortunately, there are but few of these on the Pacific Coast, these chiefly in the genus *Pocalta* Csy., but they are well-represented in our eastern and southern states by such genera as *Anomala* Sam., *Pelidnota* Mach., and *Cotalpa* Burm., some members of which may at times do considerable damage. It is, however, in the Oriental regions where the genus *Anomala* is particularly large that we find them doing the greatest amount of defoliation. An Oriental genus with somewhat smaller species is *Popillia* Serv. Some of these are fairly destructive in their own home, but *Popillia japonica* Newm., commonly called the Japanese beetle, a species that was accidentally introduced into New Jersey some years ago, has become in its new territory one of the most destructive of insects. It attacks practically all types of vegetation.

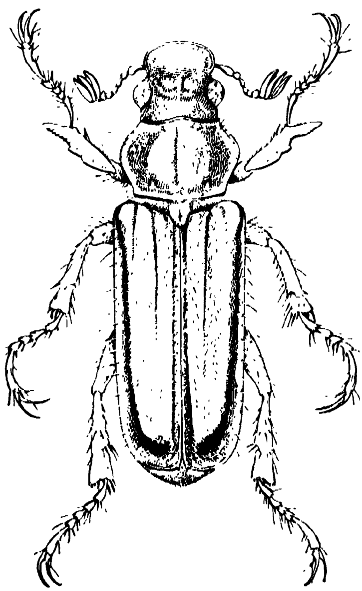

FIG. 131.—*Dichelonyx valida* Lec. × 4.

The subfamily Dynastinae are all of moderate or even large size, generally of a reddish or brownish color, and often ornamented with cephalic or pronotal horns. The larvae of some are root feeders, while those of others, chiefly the larger and more typical members, live in stumps and rotting roots. The adults generally do little injury, though the species of *Ochrosidia* Csy. and its close relatives—as a rule, straw-colored species and somewhat smaller than the average—may do some harm. *Ligyrus* Burm. and its close allies, though mainly injuring field crops in its early stages, may sometimes attack nursery stock. The large *Strategus* Hope and *Dynastes* Kby., which breed in old dead wood, chiefly roots, do sometimes extend their work so as to invade the growing tissues, thus often causing a certain amount of dying back which of course greatly weakens old trees. *Phileurus* Latr., a genus of somewhat flattened species of moderate or even large size, is,

however, one of the most typical dwellers in old stumps or hollowed-out tree trunks. The destructive rhinoceros beetle of the Orient, *Oryctes rhinoceros* L., which is accounted one of the greatest enemies of the coconut palms, is also one of the Dynastinae.

A certain proportion of the subfamily Cetoniinae are root feeders as larvae, while the species of the tribe Trichiini feed on dead wood, and the large *Osmoderma* Serv. have habits similar to *Phileurus* Latr. The species of *Valgus* Scr., rather small and flattened beetles, are found sometimes in flowers but most often tucked away beneath the bark of dead trees in which they breed, and sometimes in close proximity to the colonies of ants or termites. The only California species, *V. californicus* Horn, is to be found beneath the bark of dead ponderosa pine. The adults of many of the species of the subfamily often do considerable damage by eating the petals of flowers and in some parts of the world, as in the Orient where they are numerous, may cause considerable defoliation.

LeConte, 1856; Horn, 1884; Fall, 1901, 1928; Dalla Torre, 1912, 1913; Dawson, 1919–1922.

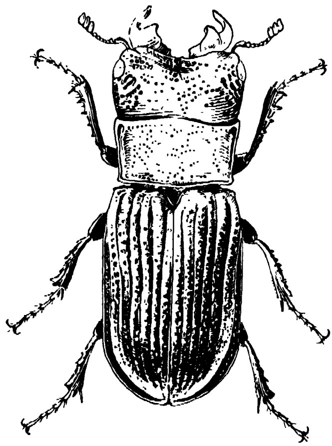

FIG. 132.—*Ceruchus striatus* Lec. × 3.

STAG BEETLES

As far as known, with the possible exception of the aberrant *Nicagus* Lec., the stag beetles, family Lucanidae, are all true wood scavengers, living during the early stages of their existence as larvae in old rotting wood, preferably in stumps and roots. The larger species, like the typical stag beetles of the genus *Lucanus* Scop. and its close relative *Pseudolucanus* Hope, which differs from the first only in having the males with mandibles but little larger than those of the females, are well-known in eastern North America and Arizona as well as in Europe and Asia but absent from the Pacific states. Here only smaller species are to be found, the three best known genera being *Ceruchus* Mach., *Platycerus* Geof., and *Sinodendron* Hellw. In the first, we have two representatives, *C. striatus* Lec., an elongate black species, from 1.5 to 2 cm. in length, with deeply striate elytra; and *C. punctatus* Lec., a somewhat smaller and flatter species, conspicuously punctured but without marked striae.

The first is confined to the coastal area from British Columbia to middle California and breeds in rotting fir in the North and the dead sapwood of the redwood in the South. The second species is found in the Cascade and Sierra Nevada Mountains and breeds in old dead fir logs and stumps. *C. piceus* (Web.) of the eastern part of the country lives in dead oak, beech, and similar woods. *Platycerus* has a number of species on the Pacific Coast. Among these are *P. oregonensis* Westw., a bluish species of rather wide range along the immediate coast which lives in dead alder, willow, California laurel, and perhaps other softwoods; *P. depressus* Lec. and its varieties, an aeneous or black species which breeds in poplars, especially *Populus tremuloides*; and *Platycerus agassizi* Lec. and its associates, smaller and more robust, bronze or black species which live in oak or madrone. *P. keeni* Csy., a very robust piceous species, is confined to the sand dunes of the northwest coast and breeds in the driftwood logs of poplar and alder. *Sinodendron rugosum* Mann. is a very rugose, cylindrical, black beetle, the males with a pronounced cephalic horn, which breeds freely in rotting alder, willow, and poplar logs.

Fuchs, 1883; Van Dyke, 1928.

THE LEAF-EATING BEETLES

The family Chrysomelidae is a very large one, the adults of which generally feed upon foliage, while their larvae may feed either aboveground on the leaves as do the adults or underground on the roots. They are especially abundant in the tropics of South America and the Orient. On this continent they are fairly numerous in the Eastern states, less abundant in the Pacific states. Many are to be found feeding on our broadleaved trees, while a number live on the conifers. A few are quite destructive. Some of the most characteristic or injurious forest species will be mentioned.

The subfamily Orsodacninae contains several genera, the adults of which are of rather small size with well-developed heads but with the prothorax narrower than the afterbody. *Orsodacne atra* (Ahr.), an all-black species, and its various colored varieties is widely distributed throughout the northern part of the country. The beetles are generally to be found in the flowers of various shrubs. *Syneta* Lec., a related genus containing moderately elongated species simulating many of the smaller Cerambycidae, is distributed throughout the forests of the northern parts of the entire Northern Hemisphere. *Syneta ferruginea* (Germ.), a light reddish-yellow species, is abundant in the forests of eastern North America. It feeds upon the birch as well as other trees. *S. simplex* Lec., somewhat similar but with head

and prothorax generally darker in the males and more hairy, ranges from Washington to middle California and feeds upon the leaves of various oaks; *S. hamata* Horn, a darker reddish-brown species with alternate elytral intervals more elevated and the sides of the prothorax serrated, ranges along the entire Pacific Coast as far as middle California and seems to prefer the young leaves of the vine maple, *Acer circinatum*. *S. carinata* (Mann.), a species much like the preceding but larger and generally straw-colored, is widely distributed throughout the fir forests of the Rocky Mountains and the Cascade-Sierra Nevada ranges and always feeds upon the foliage of the true firs, *Abies*. *Syneta albida* Lec., a species with elytra white in the males, somewhat straw-colored in the females, is to be found on alders, willows, and other stream-side plants in the Northwest and sometimes overlaps into the orchard. *Tricolema anomala* Cr., a small, elongate, reddish-bronze species, densely clothed with short pile, is frequently found feeding upon the foliage of the incense cedar, *Libocedrus decurrens* in the mountains of California. The genus *Zeugophora* Kun. contains a number of small species, less than 5 mm. in length and of various colors—slate, yellow, or varicolored—which are generally to be found on the poplars or willows, to the former of which they sometimes do some damage.

The members of the subfamily Cryptocephalinae are all short and more or less cylindrical in shape. They are very abundant, particularly the members of the genus *Pachybrachys* Redt. and *Cryptocephalus* Geoffr., and especially in the South and Southwest. Many of them feed as adults on the foliage of trees or shrubs and, though rarely injurious, are always much in evidence.

Most of the beetles of the moderately large subfamily Eumolpinae are rather convex and robust, sometimes brilliantly metallic. The larvae are always root feeders, sometimes doing considerable damage, as is the case with several of our grape root species. The adults always have their heads bent down and to a great extent concealed beneath the anterior part of the prothorax. When disturbed they readily drop to the ground. Most species live as adults on shrubs or low vegetation, though others are restricted to various types of trees. Among the common species of forest areas are *Adoxus obscurus* (L.), a small species, piceous or piceous with light-brown elytra, generally to be found on the fireweeds, *Epilobium*, but often overlapping and quite seriously attacking the grapevine, therefore often called the grape root borer. The genus *Glyptoscelis* Lec. contains a number of robust, bronzed beetles, 5 mm. or more in length, and somewhat densely clothed with scales or short appressed hair. *Glyptoscelis illustris* Cr. is one of the largest of the species, of a bright, coppery color with

much of the upper surface denuded of pile. It is found feeding on the needles of the ponderosa pine, in Oregon and California, during the early part of the season. *G. squamulata* Cr., a species densely clothed with silvery white or gray scales and widely distributed throughout middle and southern California, lives upon many native shrubs and at times attacks the buds of grapes, doing considerable damage. The commonest western species is *G. sequoiae* Blaisd., a medium-sized, bronzed beetle, rather densely clothed with fulvous or gray hair. It is widely distributed throughout the mountains of Oregon and California and in the early summer abundant on the foliage of the incense cedar, *Libocedrus;* the juniper; cypresses; and sometimes the sequoias. In Oriental regions, there are many species, some harmful to mulberries, others attacking the walnut, oak, and similar trees.

All the members of the subfamily Chrysomelinae, larvae as well as adults, are found feeding together. *Calligrapha scalaris* Lec., a very convex, elliptical-shaped beetle with straw-colored elytra ornamented with bronzed serpentine markings, is often rather injurious to the wild plum; while *C. bigsbyana* (Kby.), a somewhat similar species, often completely defoliates the willows over extensive areas. The various species of *Chrysomela* L. (*Lina* Redt., *Melasoma* Steph.) are somewhat flatter than the preceding and breed, in general, on the willows, poplars, or alders. *Chrysomela scripta* (Fabr.), a straw-colored beetle with elongate black spots, though as a variety sometimes entirely bluish black (var. *confluens* Rog.), as in California, or even entirely reddish brown, attacks both poplars and willows and sometimes completely defoliates the latter. It is, of course, of decided economic importance where the willows are raised for osier production. *C. lapponica* (L.), a somewhat similar species but in general more reddish in color and with the spots very irregular, less elongate, also feeds on the willow in eastern North America but on the Pacific Coast almost entirely confines its attention to the alders. *C. tremulae* (Fabr.), a larger species, with greenish head and prothorax and reddish elytra, was introduced into the northeastern part of North America some years ago and only recently has found its way to the Pacific Coast. It lives on both willows and poplars and at times completely defoliates the latter. It is now well-established in parts of northern California, as in Plumas County. One of the smaller species of the genus, *C. californica* (Rog.), an all dull-green species, about 12 mm. in length, is sometimes very abundant on willows in the central parts of California. Where many larvae of the genus *Chrysomela* are found feeding, a pronounced musky odor is always to be observed. In Europe and northern Asia, many of the species of

Chrysolina (*Chrysomela Auct.*) and its smaller relatives *Phytodecta* Kby. are also very common on the willows and alders.

The beetles included in the subfamily Galerucinae are, in general, of rather small size, somewhat elongated or elliptical, and flattened. The larvae as well as adults often feed on the foliage and, as is the case with most Chrysomelidae having similar habits, the larvae skeletonize the leaves while the adults eat out large areas in the leaves. Many of the members of this group are terribly destructive to foliage in various parts of the world. Fortunately, we have but a few which are so in this country. Among the tree-feeding species, we shall mention, first, the introduced elm leaf beetle, *Galerucella xanthomelaena* (Schrank). This is a small, slate-colored species, generally with dull-yellow vittae on its elytra. It is supposed to have been introduced into northeastern America as early as 1837 (Glover) and is now well-established, especially in towns where, when not controlled by spraying, it takes a heavy toll on all types of elms. It appeared in the Willamette Valley of Oregon about fifteen years ago and in 1924 was first noticed in the San Joaquin Valley of California, having been transported from the north, supposedly through the agency of the automobile. It bids fair to extend its range throughout the entire coast but will, of course, be confined to the settlements, for we have no native elms on the West Coast. A native species of the subfamily, the great elm leaf beetle *Monocesta coryli* (Say), a pale-yellow beetle more than 12 mm. long with two large blue spots on each elytron, has been reported by Riley (1878) as doing great damage to the slippery elm in Missouri. *Galerucella tuberculata* (Say), a native species of a uniform pitchy color, is often to be found feeding on willows, on the Pacific Coast. Certain members of the genus *Diabrotica*, as *D. soror* Lec., often attack the foliage of trees, though they usually confine their attention to shrubs and annuals. *Luperodes bivittatus* Lec., a small black and yellow vittate species, often attacks the California buckeye in considerable numbers, while certain of the brilliant-green species like *L. varipes* Lec. and *L. smaragdinus* Lec. may be found on both foliage and flowers of the various species of wild lilac, *Ceanothus*.

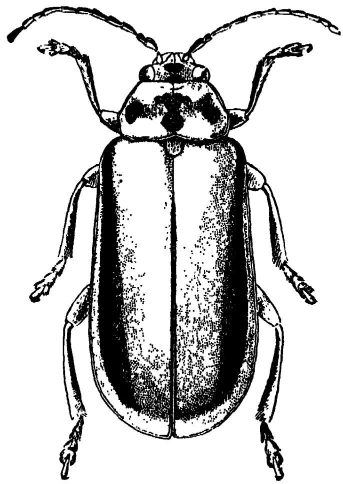

FIG. 133.—The elm leaf beetle, *Galerucella xanthomelaena* (Schr.). × 7.5.

THE FLEA BEETLES

The members of the subfamily Halticinae differ from those of the preceding subfamily in having large hind femora and great jumping powers, hence well meriting their common name. The great majority are small and mostly feed upon low herbage. Many are destructive to garden plants or truck crops, a limited number only feeding upon vines or trees. *Blepharida rhois* (Forst.), a somewhat large species for the group, 6 mm. in length, very convex and with red blotches on a straw-colored background, feeds on the staghorn sumach. Its range extends from the Atlantic states to Arizona. *Oedionychis* Latr., a genus with a large number of species, characterized by having the last tarsal segment globose at its extremity, contains a few species like *O. quercata* (Fabr.), which feed upon oak leaves and sometimes do considerable injury. *Disonycha* Chev., with a certain proportion of its members, vittate or red and white striped, contains a few species common on willows, particularly on the olive-green sand-bar willow, *Salix sessilifolia*. The typical genus *Haltica* Geoffr. (*Altica*), another large genus, contains several species of economic importance to the forest. Such is *H. bimarginata* Say, a dull-green species with the sides of the elytra definitely carinated. It ranges clear across the continent and feeds, in the main, upon alders. In parts of California, as in Plumas County and the San Bernardino Mountains, there have been numerous severe outbreaks when the alders have been almost completely defoliated over extensive areas. The small *Chalcoides helxines* (L.), which varies in color from bronze to green, is found everywhere as a common dweller on the willows.

All the members of the subfamily Hispinae are somewhat flattened, most of them with the upper surface reticulately sculptured and the antennae short and robust. The larvae are leaf miners. In the tropics numerous very destructive species are to be met with, such as the leaf miners of the coconut and bamboo, but in our territory they are less numerous and less destructive. Few of ours, however, are arboreal. *Chalepus dorsalis* Thunb., a yellow species with black dorsal stripe, is very common at times on the black locust, *Robinia pseudoacacia*. *Baliosus californicus* (Horn) and *Brachycoryna hardyi* Cr., small yellow and red species, breed freely in the leaves of many species of wild lilac, *Ceanothus*, on the Pacific Coast and often do considerable damage.

THE TORTOISE BEETLES

These beetles, subfamily Cassidae, are much flattened, more or less circular or elliptical in outline and with the head completely concealed

from above. In the tropical parts of the world, as in Central and South America, many are large and gaily colored and often abundant on trees. In our country the species are all more or less small and generally dwell, larvae as well as adults, on the smaller plants. *Jonthonota nigripes* (Oliv.), a reddish species with a black spot on each elytron, may be found on the willow. In life the adult, like many of its relatives, is quite golden in color.

THE WEEVILS

To the group known as weevils belong a large number of beetles characterized principally by having the head more or less prolonged into a beak or snout. Many of these are of great economic importance in the orchard, field, and garden, but only a few, mostly belonging to the family Curculionidae, are of interest to the forester.

To the genus *Pissodes*, tribe Pissodini, belong a number of our most destructive forest species. The members of this genus vary from about 3 to 7 mm. in length, are either reddish-brown or pitchy in color, with robust beaks, the elytra more or less parallel basally, and with more or less transverse patches of white or ochraceous scales near the base and at the summit of the declivity. The patches of scales near the base of the elytra are much reduced or absent in a number of our species, chiefly the darker species. The normal breeding place for these insects is in the sapwood areas of standing dead trees, the larvae making their burrows in an irregular manner through the wood and coming to the surface when they are mature to form a peculiar pupal cell with the cap or cover made of small shavings and projecting slightly beyond the surface of the timber. The peculiar projecting cells are always diagnostic. When these beetles live in this manner they are true forest scavengers and thus beneficial. They do not, however, always elect to breed in this manner. They may seek out the various branches or the main shoot of young trees, and the females deposit a series of eggs along the twig. The young larvae work along the pith channel or in the cambium or, if crowded, partly in the wood, complete their development, and pupate by the next year, the adults emerging in late spring or early summer. The twigs grow for a time after being attacked but before long wither and die. More or less exuding pitch is generally to be found on such

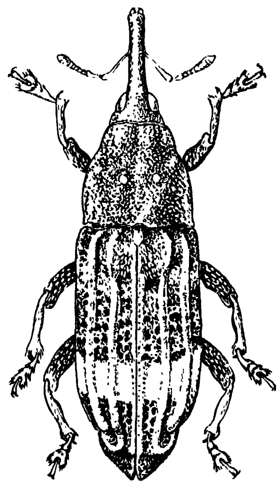

FIG 134.—*Pissodes radiatae* Hopk. × 7.5.

twigs, distinguishing them from the dead twigs attacked by several other types of beetles. When the attacked twigs or branches are lateral, the tree soon presents a ragged appearance, but when the branch is the central shoot, the tree naturally suffers much more. In a young tree the aftergrowth causes it to assume a bushy appearance, of course rendering it worthless in after years for timber purposes.

The white pine weevil, *Pissodes strobi* (Peck), is 5 or 6 mm. in length, of a reddish-brown color, and with the two bars of scales well-marked. It has for a long time been considered one of the most destructive insects of the white pine in northeastern America, being particularly harmful to nursery stock and young plantations. It also attacks spruce. Various methods of combating the ravages of this weevil have been proposed. In new plantations the earlier planting of more rapidly growing species of trees such as Scotch pine will sometimes aid by affording shade and protection to the later-growing white pines. In young plantations infested shoots may be cut and burned in late June or early July, or the beetles may be collected in a net. The weevils will fall into the net if the low shoots and leaders are tapped with a stick.

FIG. 135.—Work of *Pissodes terminalis* Hopp. in terminals on lodgepole pine. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Photo by Salman.*)

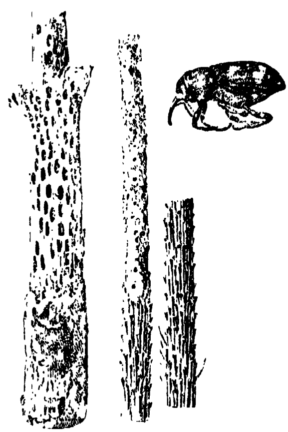

FIG. 136.—*Pissodes sitchensis* Hopk. and work in Sitka spruce. × 1.5. (*U. S. Dept. Agr. Bur. Entomol. Plant Quar. Edmonston.*)

In the southern states, the common pine *Pissodes* is *P. nemorensis* Germ., while *P. yosemite* Hopk. and *P. terminalis* Hopp. are the

best known species on the Pacific Coast. *P. yosemite* attacks primarily the ponderosa pine, apparently doing little real injury, while *P. terminalis* confines its attention to the lodgepole pine, doing at times a great amount of damage. This last species has been found by both Hopping and Salman to work much as does *P. strobi* and at times to distort much young lodgepole-pine growth. *P. piperi* Hopk., a much larger and pitchy-colored species with a limited amount of white, scaly marking, ranges from the northern Cascades to the middle Sierras and is generally to be found on the true firs.

FIG. 137.—Pupal cells of *Pissodes costatus* Mann. in Sitka spruce. This illustrates the excelsior-like material used in making the pupal cells by members of this genus.

P. radiatae Hopk., a reddish species with the hind angles of the prothorax acute, frequents the Monterey, Bishop, and other beach pines along the Pacific Coast. *P. fasciatus* Lec., a widely distributed species on the Pacific Coast, is confined mainly to the Douglas fir; while *P. sitchensis* Hopk., a small black species, selects and greatly injures at times the Sitka or tideland spruce along the northern Pacific Coast. *P. terminalis* Hopp. destroys the tips of lodgepole pine, and *P. costatus* Mann. works in Sitka spruce. Other western species of more or less importance are: *P. barberi* Hopk. in Sitka spruce; *P. burkei* Hopk. in *Abies; P. californica* Hopk. in ponderosa pine; *P. engelmanni* Hopk. in *Picea; P. murrayanae* Hopk. in lodgepole pine, and *P. webbi* Hopk. in sugar, white, and ponderosa pine.

Most of the members of the tribe Hylobini in North America live as scavengers in the stumps and dead trunks of coniferous trees.

Normally they are rather beneficial than otherwise. When, however, new plantations have been started in old cutover areas, and pains have not been taken to rid the territory of the old stumps and dead and rotting timber, serious consequences may result. The most destructive species is *Hylobius pales* Boh., a large, black weevil, 6 mm. or more in length. This breeds freely in the old logs and stumps and when mature wanders forth in search of food. If young trees are near, these proceed to feed on the bark not far from the ground level and of course girdle and kill or greatly weaken the tree. In numerous pine plantations in New England, this species has taken a heavy toll. Fortunately the only Pacific Coast species of the tribe, *Steremnius tuberosus* (Boh.) (*Paraplinthus carinatus* Boh.) has remained purely a scavenger. In Europe and Asia, several close relatives of *Hylobius pales* Boh., notably *H. abietis* L., have long been known as insects most destructive to nursery stock and young plantations.

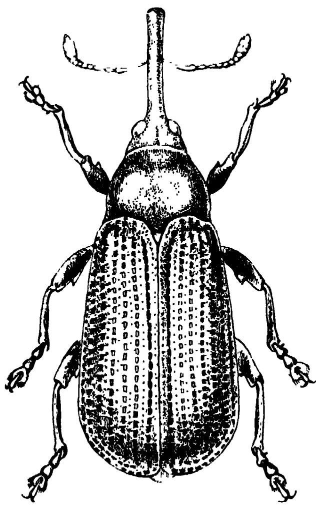

FIG. 138.—*Magdalis lecontei* Horn. × 7.5.

The genera *Magdalis* Germ. and *Trichomagdalis* Fall. comprise the tribe Magdalini. All of the species are wood-boring, living in the larval stage either in twigs or in the sapwood areas of dead trees. Of the numerous species of *Magdalis*, the following might be mentioned: *M. lecontei* Horn, a somewhat robust blue species almost 6 mm. in length, found abundantly about dying or recently killed ponderosa pines throughout the entire Pacific Coast; *M. cuneiformis* Horn, a somewhat similar species, though narrower, more cylindrical, and of a greenish-blue color, found with the preceding, though less common; *M. subtincta* Lec., a dull-black species which breeds in dead alder and willow along the Pacific Coast; *M. aenescens* Lec., a bronze-black species of the Pacific Northwest which breeds normally in the wild hawthorn, *Crataegus*, and related trees, though frequently overlapping on to the cultivated apple or pear; and *M. gracilis* Lec., a closely related black species which takes its place in California. *M. aenescens* Lec. and *M. gracilis* Lec. may at times do considerable damage to old neglected apple trees by attacking the branches, sometimes producing fusiform branch galls and of course the ultimate death of the limb. The pine-feeding species as far as observed, though often abundant, merely breed in the dead and dying twigs or dead outer wood and do

no appreciable amount of damage. The species of *Trichomagdalis* are confined to California and breed in the dead twigs or branches of various species of oak. *Trichomagdalis conspersus* Fall, the only common one, is black, sparsely clothed with fulvous pile. It is sometimes attracted in numbers during the spring to the branches broken or killed by the previous winter's storms.

The nut-weevils, tribe Curculionini, are limited to one genus, *Curculio* L. (*Balaninus* Germ.) as far as North America is concerned. The adult beetles are robust, densely clothed with gray or yellowish-brown hair, with long legs and very long and curved rostrums. The females, with their extremely long beak, drill a hole a considerable distance into the developing nut or acorn and lay their eggs at the bottom. The larvae soon hatch, feed upon the kernel, and when mature gnaw their way out of the nut or acorn, drop to the ground, burrow in, and soon hollow out a cell in which to pupate. The following spring or summer they emerge as adults. There are many species, and some are to be found in most parts of the country. As a rule, each species limits its attention to one type of nut or variety of acorn, but at times they may utilize several different kinds of food. The amount of injury that they do is often very great, for they not only prevent the fruit from properly developing, thus cutting down the crop of nuts and acorns, but often materially affect forest reproduction.

Among the more important species which might be mentioned are *Curculio proboscideus* Fab., the larger chestnut weevil, a beetle nearly 12 mm. in length, the beak in the female 15 mm. long, of a yellow color mottled with shades of rich brown, and confined to the regions where the true American chestnut is native; *C. auriger Csy.* (*rectus* Say), the chestnut or lesser chestnut weevil, a beetle of smaller size than the preceding, darker color, shorter and more curved beak, found from Canada to North Carolina and westward to Ohio and Tennessee, and very destructive to both chestnuts and chinquapins; *C. caryae* (Horn), the hickory nut weevil, a beetle intermediate in size between the two preceding and of a dull, dark-brown color, attacking practically all types of hickory nuts and sometimes destroying as much as 20 per cent of the shellbark hickory crop in the North and often from 50 to 75 per cent of the pecan crop in the South; *C. obtusus* (Blanch.), the hazelnut weevil, similar in color to the chestnut weevils but readily distinguished by its more robust form and very much shorter beak, a beetle found throughout the area east of the Mississippi River and quite destructive at times to the hazelnuts; *C. rectus* (Say) (*quercus* (Horn), the commonest and largest of a large number of eastern acorn weevils, attacking primarily the biennial oaks such as the red oak; and *C. uniformis* (Lec.), a somewhat mottled yellowish-brown species

found widely distributed throughout California and at times quite destructive to acorns of many species of oaks.

The tribe Zygopini contains a moderate number of small, triangular weevils, rather attractively ornamented with colored scales and with the ability to press the legs and beak close against the body when disturbed. Breeding in the bark of various species of pine are two rather common species of *Gelus* Csy., both ornamented with reddish-brown scales. *Gelus oculatus* (Say) is found in the eastern part of our country, and *G. californicus* (Lec.) on the Pacific Coast. In the genus *Cylindrocopturus* Heller., containing more elongate species, there is one, *C. quercus* (Say), which breeds in oak and another, *C. longulus* (Lec.), more or less covered with silvery white or bronze scales, which breeds freely in the twigs of various species of pine, fir, and the Douglas fir. This last has been reported on several occasions to have done considerable damage.

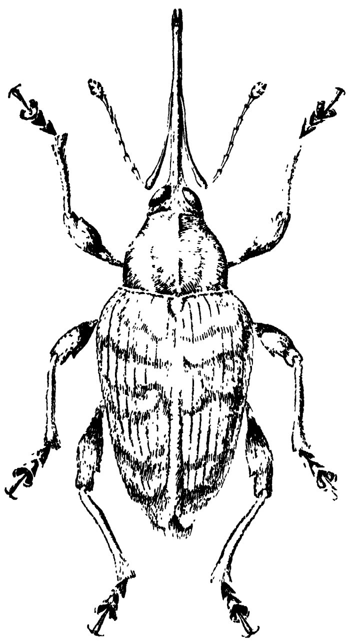

FIG. 139 *Curculio uniformis* (Lec.). × 7.5.

The weevils of the tribe Cryptorhynchini are very compactly built and have the beak when at rest tucked away in a deep groove in the breast. They are more or less irregular in outline, variously ornamented with tubercles, ridges, or patches of colored hair, and when feigning death look much like a small bit of bark. The most important genus from the forester's standpoint is *Conotrachelus* Schon., containing the well-known plum weevil, *C. nenuphar* (Hbst.). Among the other species are *C. juglandis* Lec., a pretty species a little less than 6 mm. in length, with a crescentic patch of white near the apex. This is the butternut curculio which breeds in the husks of half-grown butternuts, causing them to drop before they are ripe. *C. retentus* (Say), a smaller species, attacks the young black walnuts; *C. affinis* Boh., a somewhat similar species, attacks the young hickory nuts; while *C. aratus* (Germ.), a small species with a bar of yellow across its middle, attacks the tender tips and leaf petioles of hickory. *Cryptorhynchus lapathi* (L.), the mottled willow and poplar borer, is somewhat larger than the preceding and with a rose patch at the apex of the elytra. It is a species introduced from Europe, appearing in the

northeastern part of the United States sometime prior to 1887, and, gradually extending its territory since, now found as far west as the Pacific Coast. This beetle injures the twigs and breeds in the smaller limbs of the living willows and poplars, boring irregular tunnels through them and causing the bark to crack in an irregular manner or long fusiform galls to form. The twigs, being girdled, of course soon die. These beetles are most destructive to both poplars and willows. When found, an effort should always be made to stamp them out, chiefly by cutting and burning all infested trees during the winter months.

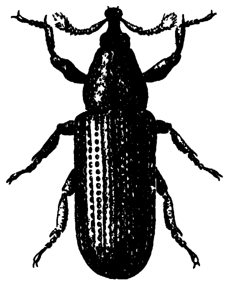

FIG. 140.—*Cossonus piniphilus* Boh. × 6.

Most of the members of the tribe Cossonini are quite small, much elongated, black or brown beetles. The majority are scavengers living in old rotting wood, and as such are not harmful. Some, however, are quite common in the forest, therefore often met with by the forester and rather apt to be confused with the more destructive bark beetles. Among these are the various species of the genus *Cossonus* Clairv., elongate, flattened, black beetles, from 3 to 6 mm. in length, and with the beak dilated at the apex. These generally establish themselves beneath the bark about the time that the sap begins to sour and are thus readily exposed when the bark of a dead tree is removed. The larvae live in the sapwood and, when numerous, honeycomb it much in the same way that the larvae of death watches do. The common species on the Pacific Coast are *Cossonus piniphilus* Boh., a shining black species with a wedge-shaped prothorax, found on the Monterey, Bishop, and beach pines and ranging from middle California along the coast to British Columbia; *C. ponderosae* Van D., a duller black species with a broad elliptical prothorax, found generally about the ponderosa and sugar pines and met with more in the interior of the country; *C. pacificus* Van D., a very flat, shining species found in the Sierras beneath the bark of the black poplar; and *C. crenatus* Horn, a smaller and more cylindrical species with the dilated apical portion of the beak longer than the basal portion, found also under the bark of the ponderosa, sugar, and various other species of pine, and

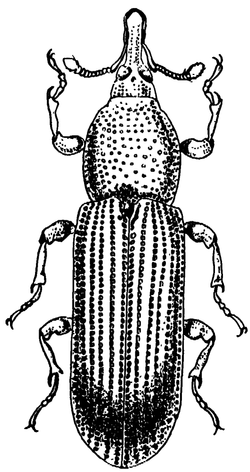

FIG. 141.—*Cossonus ponderosae* Van D. × 10.

ranging from southern California to British Columbia. The common species in the eastern states are *C. impressus* Boh., a dull-black species simulating *C. ponderosae* and found widely distributed and generally beneath the bark of pines; *C. platalea* Say, a flatter, shining black species found beneath the bark of butternut, poplar, and other similar broadleaved trees; and *C. corticola* Say, a smaller species resembling *crenatus* and distributed rather widely over the country. The genus *Rhyncholus* contains species somewhat similar in appearance

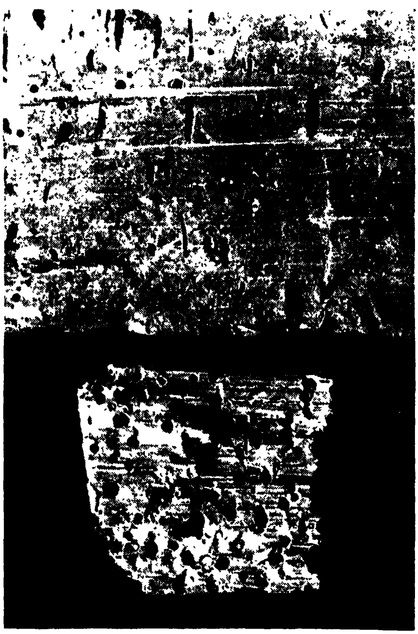

FIG. 142.—Work of the larvae of *Cossonus ponderosae* Van D. in old ponderosa pine log

to *Cossonus* but smaller, more cylindrical, and with the beak shorter, more robust, and not dilated apically. The species have habits similar to those of the preceding genus. The only two important species are *Rhyncolus brunneus* Mann., a dark-reddish species, found widely distributed throughout the coniferous forests of the northern part of the country and apparently as much at home in the wood of spruces and firs as of the pines; and *R. oregonensis* Horn, a jet-black species with the elytra more definitely carinated, found widely distributed in the pine forests of the Cascades and Sierra Nevada Mountains. The species of *Rhyncolus* seem to prefer dryer wood than do most of those of *Cossonus*, hence are more often found near the ends of logs.

The broad-nosed weevils, subfamily Brachyrhininae (Otiorhynchinae), includes a large number of beetles characterized by having

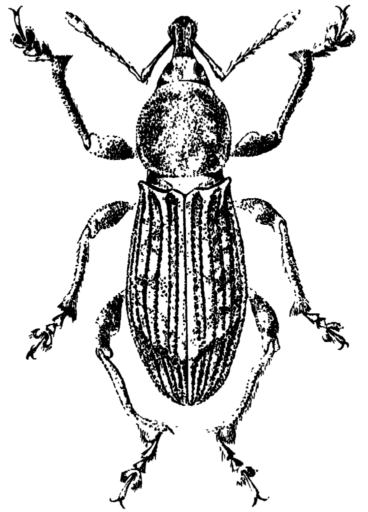

FIG. 143.—*Dyslobus segnis* (Lec.). × 4.

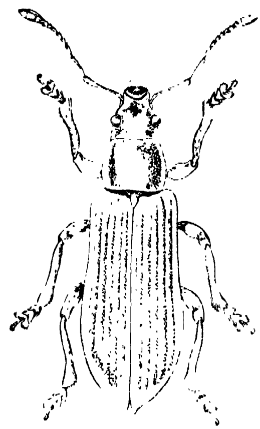

FIG. 144. *Scythropus elegans* (Couper). × 2.

a broad beak and deciduous apical piece to the mandibles. This group contains many members that are true forest insects. The larvae are subterranean root feeders, while the adults are more or less free-ranging foragers, sallying forth at night to climb the shrubs or trees and feed on the buds, young fruit, or foliage. This applies particularly to the greater number in our country which are wingless. A certain proportion have fully developed wings. These are generally not only more brilliantly colored, often of a beautiful metallic green, but also apt to be diurnal. The larvae have not been proved to be particularly destructive in the virgin forest. They might, however, be injurious to young nursery stock and small trees. The adults have often been caught eating off the bark or girdling young trees as well as feeding on the buds or young fruit. The damage to the foliage of older

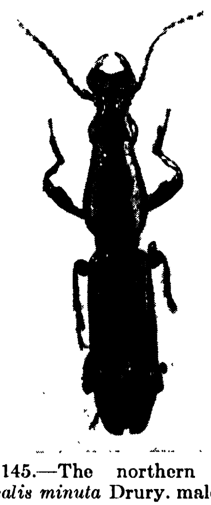

FIG. 145.—The northern Brenthis. *Eupsalis minuta* Drury. male. × 4.

trees is, as a rule, not great. The following genera are quite characteristic of the forests of the Pacific Coast: *Dyslobus* Lec., moderate to large brown weevils found on the shrubs along the streams or about the clearings as well as on the lower limbs of the forest trees themselves, especially the true firs; *Adaleres* Csy., contains large gray or brown species, particularly attached to the oaks in both middle and southern California; *Panscopus* Schon., with numerous small or medium-sized species, having habits similar to those of *Dyslobus*, though preferring, as a rule, the shrubs and annuals like the lupines; and *Scythropus* Schon., a genus of elongate, winged species, brown, gray, or greenish in color, and always to be found feeding on the needles of the pines and other conifers during spring and early summer. *Mimetes* Schon., willow- and shrubfeeding species, have within recent years done considerable damage to the buds of various trees in California. *Paraptochus* Seid. and *Tricolepis* Horn., small weevils with more or less globular bodies, often frequent the various oaks or shrubs in great numbers and do at times an appreciable amount of injury.

Within recent years we have suffered to a considerable extent from several species of the typical genus *Brachyrhinus* Latr. which have been introduced from Europe. The larvae of these species feed upon the roots of a variety of plants including young conifers. Sometimes they cause considerable damage to small trees while they are in the nursery or soon after they are transplanted.

Eupsalis minuta Drury, belonging to the family Brenthidae, is a cylindrical beetle 12 mm. or more in length, of a reddish brown color with the elytra more or less maculated with yellowish-white markings. This species is widely spread throughout eastern North America and breeds freely in dead and dying oak, also in chestnut, beech, elm, and most other species of deciduous trees. The larvae often excavate extensive galleries in the timber, thereby, of course, rendering it worthless.

Le Conte and Horn, 1876; Brooks, 1910; Hopkins, 1911; Fall, 1913; Van Dyke, 1915*a*; Carter, 1916; Blatchley and Leng, 1916; Chittenden, 1927; Taylor, 1930.

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CHAPTER VIII

THE MOTHS AND BUTTERFLIES

Next to the Coleoptera, the Lepidoptera is undoubtedly the most important order of insects affecting forest trees. In the aggregate there are probably several hundred species of moths that do some damage to forests and forest products, but the major portion of the injury is inflicted by a comparatively few species such as the spruce budworm, gypsy moth and browntail moth, hemlock looper, and white pine butterfly. These are all defoliators whose larvae feed on the needles of conifers and leaves of broadleaf trees, thus depriving the plant of its power to assimilate and manufacture food. Where defoliation is not too severe, the trees would often recover were it not for the fact that their weakened condition renders them very susceptible to bark beetle attack or attack from other destructive pests which enter and kill the trees. Thus defoliators may be directly or indirectly responsible for the death of the timber in all stages.

Aside from those species whose caterpillars devour the foliage, there are many other forms whose work occasionally causes the death of the host, reduces the increment, causes defects, or destroys products of the trees. This latter class includes the many species that work in the cones of conifers and the nuts and seeds of broadleaf trees. It includes also the leaf and needle tiers; the leaf and needle miners; the species working in the cambium (Aegeriidae) which either kill the tree or cause defects; and the boring caterpillars (Cossidae) which ruin the timber value of the trees.

More than 9,000 species of Lepidoptera are found in North America.

The outstanding characteristics of the order are the presence of two pair of wings which are clothed with scales; the forewings are larger than the hind wings. The venation of the wings is characteristic and so constant as to form the principal basis for separating the order into families. In most species the mouth parts are modified into a characteristic long, slender, flexible, sucking proboscis. This tube is formed of the elongate maxillae which are grooved and fitted together. In the case of some of the large species which feed on the nectar of deep flowers, this tube may measure 4 or 5 in. in length when extended. When not in use it is rolled up like a coiled watch spring.

The larvae or caterpillars are well-known and readily recognized. They are characterized (with few exceptions) by possessing three pairs

of jointed legs on the first three segments behind the head and from three to five pairs of short, fleshy, unjointed legs called prolegs on the abdominal segments. The mouth parts are formed for biting.

The larvae of most moths spin a more or less dense cocoon for the protection of the inactive pupae. The pupae of butterflies are known as chrysalids. They are not protected by a cocoon but are usually suspended by a silken structure at the posterior end. Many have a silken girth or bridle around the middle to help support the body.

The order Lepidoptera is very conveniently divided into two groups, the moths and the butterflies. They are easily distinguished in the mature stage by the following characters:

1. Moths: Antennae variously formed but never filiform with the tip knobbed. Usually, but not always, night or twilight fliers. Wings usually folded along abdomen or spread horizontally when at rest; pupa often enclosed in a silken cocoon.

2. Butterflies: Antenna slender for most of its length, with the tip dilated to form a knob. Mostly day fliers; wings held vertical when at rest; pupa in the form of a chrysalid never enclosed within a cocoon.

Moths or millers are by far the most numerous and economically the most important members of the order Lepidoptera. More than sixty families are recorded from North America. It must serve our purpose to discuss only a few of the families which are of more or less interest to the forester.

DEFOLIATORS

As many of the worst pests belonging to this order belong to the groups that attack and destroy the leaves, they will be discussed first.

The Leaf Rollers

More than 165 species of the family Tortricidae are known to occur in the United States and Canada. Owing to the fact that many species have the habit of rolling the leaves of plants in various ways to form their homes, the family has come to bear the common name of "leaf rollers." However, many species do not roll the leaves of their host plant, and the larvae of many mine into the tissue of plants, into fruits, and under the bark. The forester will come to know the individual species much more readily by the character of the damage done and by their host plants than he will by a study of the individual species without linking it up with its host and character of work.

The most important members of this family attacking conifers are the spruce budworm, which is widely distributed, and the blackheaded spruce budworm, which occurs in the Pacific Northwest.

The spruce budworm, *Cacoecia fumiferana* Clem.—The spruce budworm is probably the most destructive enemy of balsam, spruce, fir, and, at times, hemlock in America and is one of the most destructive of all insect enemies of the forests.

Swaine (1933) says of this species:

The ravages of the budworm during the last twenty years, in which such enormous quantities of timber were killed, probably constituted the most destructive forest-insect outbreak that has ever been recorded. It has been

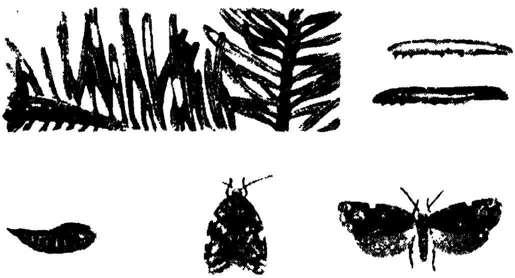

FIG. 146.—Spruce budworm *Cacoecia fumiferana* Clem. Natural size. (*Spec. Circ. Can. Dept. Agric. Div. Forest Insects.*)

estimated that in eastern Canada alone more than 200 million cords of balsam and spruce were destroyed. The vast amount of this loss can be better appreciated by comparing it with the losses caused by fires. It has recently been estimated by one of our most competent foresters that fires have destroyed balsam and spruce in eastern Canada during the last twenty years to the amount of approximately 70 million cords. The spruce budworm alone destroyed three times as much.

The adult moth has a wing expanse of about 25 mm. The fore-wings are overlaid with bands, streaks, and spots of reddish brown. In the middle of the upper margin of the front wings is a rather large, conspicuous, whitish spot. The hind wings are dark and fuscous. The body of the moths may vary in color from reddish brown to yellowish gray.

When young the larvae have a greenish tint but become dark brown as they approach maturity. The body bears conspicuous whitish-yellow tubercles and has a yellowish stripe running along the side. When mature the caterpillar is almost 25 mm. in length.

The pupa is thick and striped with darker brown; antennae and legs are dull tan.

The eggs are laid on the sides of the needles about the middle of July. They hatch in about ten days. The young larvae then feed

on the terminal shoots for a short time and hibernate as very small caterpillars in a little shelter constructed near the bud. They appear again in spring in time to attack the opening buds of their host, becoming full-grown in June or July, when they pupate in their loosely made shelters. The moths emerge a week to ten days later and deposit their eggs. There is one generation a year.

The first indication of an attack is in the late spring or early autumn when trees look as if a light fire has passed through them. The little caterpillars feed upon the needles of the new buds or terminal shoots. They gnaw the base of the needles, separating them from the twig, and bind them together by means of silken threads. These shelters are used for both pupation and hibernation. When the moth appears it drags the empty pupal case practically out of the larval shelter. The adults are strong fliers, and infestation spreads rapidly over a wide range of territory.

Fir, spruce, Douglas fir, larch, hemlock, and white pine are attacked. Firs are most susceptible (especially balsam). White and Norway spruce are also very susceptible, as are other conifers in the West.

The insect is distributed over eastern Canada, the New England states, New York, Pennsylvania, southern Canada west to Manitoba, Vancouver Island, Idaho, Montana, California, and New Mexico.

Several birds are known to prey upon these insects, the most important of these being the purple martin which feeds on both pupae and larvae.

A number of hymenopterous and dipterous parasites have been reared from the various stages of this insect.

While it is impracticable to attempt control of the spruce budworm under forest conditions by ordinary spraying methods, considerable success has followed the use of calcium arsenate dusted from an airplane. Ornamentals and shade trees can be kept free by spraying with lead arsenate (2½ lb. to 100 gal. of water) shortly after the new buds appear and repeating the application in seven to ten days' time.

The hemlock budworm, *Peronea variana* Fern.—This species has from time to time proved to be quite injurious to spruce and hemlock in Alaska and in other regions in the Pacific Northwest. It occurs also in the Northeastern states and in Canada. It feeds chiefly on hemlock but may attack spruce and firs also. The color of the moth shows considerable variation from brown to gray, the wing spread being about 16 mm. Eggs are deposited in late July and August. The caterpillars, when grown, are green with a brown head, and 18 mm. in length. They feed on the needles and young twigs.

Winter is passed in the caterpillar stage. In the spring feeding is resumed, and pupation takes place in July or June.

Trees are seldom entirely defoliated, but one-third to one-half the leaf surface is destroyed, the dead leaves and webs give the trees a bad appearance, and growth is seriously interrupted. In 1929 a serious outbreak occurred on an area of 150,000 acres on the Olympic Peninsula. In 1930 some 500 sq. miles in eastern Canada was infested.

An ichneumon parasite is common in the pupa and is probably one of the greatest factors in keeping this moth under control.

Pine tube moth, *Eulia pinatubana* Kear.—This is a small, slender moth of a grayish color with a wing expanse of about 12 mm., the head, forewings, and thorax of a rust-red color. The forewings have two light-colored, oblique lines crossing them; the hind wings and the dorsal side of the abdomen are silky gray.

Eggs are deposited on the pine needles mostly in May. The larvae live in tubes which are formed by drawing together the needles of the host and binding them with silken threads, from five to twenty needles being used in the construction of a tube. The first tube is formed of five needles, a single fascicle, but, as the larvae grow, more and more leaves are brought in for them to feed upon.

Pupation takes place within the tube, and in this state the insect passes the winter. There is normally but one generation a year. It occurs on white pine in the East and on the lodgepole pine in the West. In the Yellowstone Park and other regions it was very destructive from 1920 to 1925.

Sugar pine catkin moth, *Tortrix lambertianae* Busck.—The larvae attack the pollen catkins and leaf buds of *Pinus lambertiana* in California and Oregon. *T. packardiana* Fern. is reported from fir.

Many deciduous trees are attacked and often seriously injured by leaf rollers.

The aspen tortrix, *Archips* (*Cacoecia*) *conflictana* Walker.—This species was very numerous on aspen, *Populus tremuloides*, in Manitoba during 1916 and at intervals in other parts of Canada. It seriously injured large numbers of trees. The caterpillars feed on the new leaves as soon as they burst from the buds, at first eating holes in them and soon afterward curling them by means of silken threads, forming funnel-shaped inclosures within which the individual larva feeds, later moving to other leaves to repeat the process. The second season's attack is usually much worse than the first, and it is reported to have killed large numbers of trees.

The oblique-banded leaf roller, *Archips rosaceana* (Harris), and the **cherry tree tortricid,** *A. cerasivorana* Fitch, are general feeders

attacking the leaves of many trees and shrubs in all parts of the United States.

The oak webworm, *Archips fervidana* Clem., and *A. grisea* Rob. attack oaks. *A. infumatana* Zell. attacks hickory, and *A. rileyana* Grote attacks hickory, walnut, and other hosts in the eastern United States. *A. semiferana* (Walk.) and *A. negundana* Dyar sometimes defoliate box-elder trees. They occur from the Atlantic to the Pacific Coast.

The fruit-tree leaf roller, *Cacoecia argyrospila* Walk., sometimes causes the death of various oaks by repeatedly defoliating them.

Peronea trisignana Rot. and *P. ferrogana* Schiff. occur on white birch in the eastern states.

Sparganothis diluticostana Wlshm. and *S. testulana* Zell. occur on oak, and *S. pettitana* Rob. is found on maple in the eastern United States.

Argyrotoxa semipurpurana Kearf. attacks oaks in the Eastern states.

Eulia juglandana Fern. occurs on hickory, and *E. quercifoliana* Fern. on oak in the eastern states.

The juniper webworm, *Phalonia rutilana* Hbn., family Phaloniidae, was introduced into this country from Europe about 1878. It has been very destructive to junipers. The brownish-yellow larvae spin a tubular web by tying the needles of the juniper together. The adult moth has a wing expanse of about 12 mm. The forewings are yellow or orange with four red bands across them. The hind wings are gray with a slight reddish tint.

The Measuring Worms

The larvae of this group, family Geometridae, are known as inchworms, measuring worms, spanworms, cankerworms, and loopers. The common names as well as the family name refer to the peculiar mode of locomotion of the caterpillar. Each step in its progress is made by drawing up the caudal end of the body, planting it firmly, extending the thoracic end out, and grasping the twig or other surface with the thoracic feet. The center portion of the body bows out with each step, giving a looping effect as the creature moves. The caterpillars although common are not often seen, owing to their habit of "growing stiff" when approached. In this stiffened state they resemble twigs to such a remarkable degree that they are not easily detected. They are leaf feeders and frequently become numerous enough to do extensive damage.

In many cases the females are wingless. The males and winged females are slender with broad wings, usually inconspicuously colored. In size they range from 25 to 50 mm. in wing expanse.

The family is a large one, comprising some 800 known species in the United States.

The green hemlock looper, *Nepytia phantasmaria* Stkr., is a medium-sized white geometrid with numerous black markings on the wings. The adults appear in late August or September, often in company with the hemlock budworm. The eggs are deposited in groups of ten or a dozen on the underside of the needles. Winter is passed in the egg stage. In mild years the winter may be passed as caterpillars. The caterpillar appearing in May and June feeds on the needles of hemlock, spruce, and to some extent Douglas fir. It is potentially capable of destruction as great as that of the western hemlock defoliator, *Peronea variana* Fern., as indicated by small outbreaks in Washington and British Columbia.

The evergreen spanworm, *Nepytia semiclusaria* Walker.—The adult is variable in color, ranging from white to gray with zigzag dark markings on the wings. The caterpillar is 25 mm. long, of a reddish-yellow color above, yellowish on the sides; it feeds on hemlock, spruce, fir, and pine in the Northern states.

The Monterey pine looper, *Nepytia nigrovenaria* Pack., is a mottled gray moth with a wing spread 36 to 38 mm., which deposits its eggs on the twigs of Monterey pine. The light-green caterpillars feed on the needles and connect the tips of the branches with webbing.

The New Mexico fir looper, *Galenara consimilis* Hein., gnaws small holes in the opening needles at the tips of the twigs, often causing the needles to wither. The older larvae eat the entire needle, sometimes stripping all of the foliage from Douglas fir and white fir in New Mexico. Limber pine may be attacked, also. The adult moths closely resemble in color the bark of the tree trunk.

The hemlock spanworm, *Ellopia fiscellaria* Guen.—The adult has a wing expanse of slightly more than 25 mm. The wings are creamy white in color, with two irregular dark bands crossing the front pair and a prominent dot between the bands. A single line crosses each hind wing. The caterpillars feed on hemlock, often killing them, and to a lesser extent on pine, balsam, and other conifers. The adults appear in mid-September to deposit their eggs in small masses on the needles and bark. The eggs hatch the following June, and the larvae feed until late August or early September, when they pupate under the bark or in crevices of the tree.

This species is widely distributed from the Atlantic Coast to the Rocky Mountains, being particularly destructive in the lake region. It has been successfully controlled by airplane dusting, using calcium arsenate at the rate of 20 lb. to the acre. In the experiments described by Fracker and Granovsky (1927) the mortality following such a

dusting was 60 to 95 per cent. The larvae died within 24 to 48 hours.

Ellopia athasaria Walk. appeared in destructive numbers in Ohio in 1925, killing hundreds of hemlock. In about two years the pest had almost disappeared, having been controlled by a fungus, *Sporo-*

FIG. 147.—Work of New Mexico fir looper, *Galenara consimilis* Hein. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar.*)

trichum globuliferum, which attacked and destroyed the pupae in the ground.

The oak looper, *E. somniaria* Hulst.—This caterpillar when hatched has a black head and gray body with black lines. When full grown it is about 25 mm. long, very slender, with three pairs of legs on the thoracic segments and two pairs at the caudal end. The color is pale yellowish brown with a fine black line down each side.

The adult is a delicate moth with angulated wings. The color ranges from pale buff to light brown, wing spread 38 to 44 mm. The male is larger than the female and has plumose antennae.

The eggs are deposited singly on twigs and moss in the fall and overwinter in this state. The eggs hatch in early summer. The larvae feed upon the leaves of the host, maturing about the middle of August, at which time pupation starts. They descend to the ground, either down the trunk or by means of a silken thread, pupating in crevices or in any protected place. Pupation covers a period of about one month, the adults emerging from Sept. 20 until cold weather sets in. The males emerge several days before the females.

FIG. 148.—Larvae of *Ellopia somniaria* Hulst. in characteristic positions. × 1.5.

Serious infestations of this looper have occurred on the oaks of southern Vancouver Island near Victoria It is reported that the insects appear in large numbers at intervals of three or four years and defoliate the oaks. The caterpillars are so numerous as to hang in festoons from the trees. Their webs blow over the surrounding territory and are very annoying. As many as 113 pupa were taken from an area 18 by 18 in. under a large oak.

In western Oregon serious outbreaks occur from time to time when the oaks over restricted areas are completely defoliated. The principal loss is to the wood lots on the farms.

In wood lots, parks, etc., several methods of control are available. A dormant spray of kerosene emulsion will destroy a large percentage of the eggs on the tree trunks, or applying any arsenical soon after the young caterpillars appear will control the species.

Fortunately, this insect has a number of natural enemies which aid in its control. In Oregon in 1930 a total of 24 per cent parasitism was obtained from five species of hymenopterous parasites.

E. pellucidaria G. & R. attacks yellow pine, and *E. endropiaria* G. & R. occurs on oak and chestnut in the Northeastern states.

The spring cankerworm, *Paleacrita vernata* Peck.—This common worm is a serious pest of orchard trees, but it is often very destructive to forest and shade trees as well.

The female is wingless, but the male has well-developed wings, the first pair brownish gray, with a broken, whitish band near the outer edge and three interrupted brownish lines between the edge and the body.

The caterpillar is of the looper type, long and slender, the dull color blending with the bark. When full-grown it is a little less than 25 mm. in length. The color may be greenish yellow, gray, dusky, or brown with paler stripes along the sides.

The female issues from the pupa and comes out of the ground to deposit her eggs from February to April, depending on latitude and season. Young caterpillars appear in April or May and attain their full growth in about a month. Winter is passed as pupae, 2 to 5 in. under the ground, and there is but a single generation a year.

The insect occurs most commonly in the states east of the Mississippi River but is also found in the West (Colorado and California).

In the case of infested forest and shade trees which are not sprayed, the cankerworm will thrive and may sooner or later destroy the trees unless measures for its control are carried out.

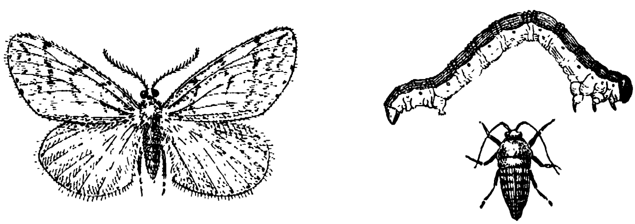

FIG. 149.—Spring cankerworm, *Paleacrita vernata* Peck., winged male, wingless female, and larva. × 1.4. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Edmonston.*)

Spraying of large trees such as the elm, on which this pest is most common, is expensive and difficult on account of their large size. So, in controlling the caterpillars, we take advantage of the fact that pupation takes place in the ground and the female, being wingless, can deposit her eggs only in such places as may be easily reached by crawling. Ordinarily, she crawls up the tree trunk and deposits her eggs in masses in the crevices of the bark. By applying a band of tanglefoot around the trunk of a tree it is fully protected against the female and also the young caterpillars. In case the worms are already in the tree, they may be killed by spraying with arsenate of lead.

Fall cankerworm, *Alsophila pometaria* Harris.—This is a common western species which devours the leaves of oak, walnut, beech, ash, chestnut, and various orchard trees. The moths are gray; the female is wingless. The olive-green caterpillar is naked, about 25 mm. long. Life history and habits are similar to those of the spring cankerworm.

The snow-white linden moth, *Ennomos subsignarius* Hubn.—These are pure white moths; the female is larger than the male and may be distinguished at once by the threadlike antennae, the male having feathered ones. The front wings are angulated, and the hind wings of the female are regularly notched, those of the male less so.

The pupa is pale brown flecked with numerous black dots which occasionally run together.

The caterpillar upon emerging from the egg is about 2.5 mm. in length and of a greenish color. After the first molt it is very dark reddish brown, with the head and last segment more conspicuously red. When full-grown it is about 50 mm. long. When disturbed it will lower itself to the ground by means of a silky thread which it spins.

The eggs are deposited in clusters on the underside of the branches in late June and July and remain there until the following April or May when they produce the tiny green caterpillars. These feed and grow for a matter of two months, becoming full-grown in June or early July when they form their pupal cells in a loose cocoon in a folded leaf. The pupal stage lasts from 12 to 16 days, and the moths appear from June 15 to July 30, depositing their eggs soon after and thus completing their life cycle in a year.

Although seeming to prefer the foliage of the linden trees, the worms readily attack beech, maple, elm, chestnut, birch, ash, hickory, and other forest and shade trees. They are sometimes called the elm spanworms.

They occur in southeastern Canada, the New England states, to Georgia, and west to Iowa and Colorado.

From 1857 to 1880 this pest was much more serious than it is at the present time. The decline is attributed to the work of the English sparrow which was introduced for the purpose of destroying the caterpillars in New York State. At the present time, though not epidemic, it is nevertheless serious in certain regions.

Shade trees may be protected by spraying with arsenate of lead (3 lb. to 50 gal. of water). The spray should be applied when the caterpillars are small.

The notched-wing geometer, *Ennomos magnarius* Guen.—The adult is yellow with a reddish tinge, spotted with brown and shaded brown along the wing margins. The caterpillar is over 50 mm. long, being one of the largest species of the family. The cocoons are found in folded leaves. The hosts are maple, chestnut, birch, and beech in the eastern states.

Bruce's measuring worm, *Rachela bruceata* (Hulst.), is less than 25 mm. long, pale green with yellowish side stripes. The adult resembles the fall cankerworm moths. It occurs on maple and other trees throughout the northern states.

The walnut spanworm, *Coniodes plumogeraria* (Hulst.), normally feeds on live oak, but it is of more importance as a pest of walnut and fruit trees. It is found throughout the western states.

The omnivorous looper, *Sabulodes caberata* Greu., is so called because it feeds on a wide range of host plants including maple, chestnut, willow, and many other trees and shrubs. It is a western species.

The large maple spanworm, *S. transversata* Drury, is one of the commonest measuring worms in some of the Atlantic states. It attains a length of 43 mm. and is found on maple, oak, and other trees. There are two broods each year.

The mottled umber moth, *Erannis defoliaria* Clerck.—The wingless female is greenish with brown or black spots. The male is winged and brownish in color with an expanse of 43 mm. The

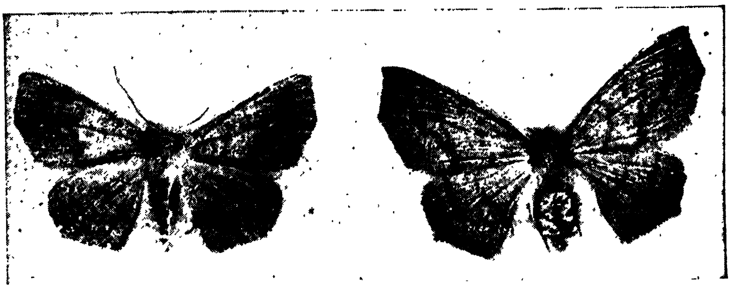

FIG. 150.—Adults of the omnivorous looper, *Sabulodes caberata* Guer. × 1.

caterpillars are brownish above, yellow-green below, and appear in April on the foliage of oak, beech, birch, and elm. The species has only recently been introduced from Europe to British Columbia.

Among other species, chiefly eastern in their distribution, the following may be mentioned: *Chlorissa subcroceta* Wlk.; *Cosymbia myrtaria* Gn.; *Nacophora quernaria* S. & A. and *Metanema quercivoraria* Gn. on oak, less common on other trees, also, *Lygris testata* L.; *Eulype hastata* L. and *Campaea praegrandaria* Gn. on birch and willow. *Paraphia unipuncta* Haw. is recorded from birch, willow, oak, elm, hickory, fir, and pine. *Nemoria bistriaria* Hbn. on black walnut; *Heliomata cycladata* Grt. on locust; *Ectropis crepuscularia* D. & S. and *Lycia ursaria* Wlk. on poplar, alder, and other trees; *Lycia cognataria* Gn., the pepper-and-salt currant moth, feeds on a variety of shrubs and trees. *Epimecis hortaria* F. on tulip trees; *Plagodis alcoolaria* Gn. and *Tetracis corcallata* Gn. on chestnut; *Hyperites amicaria* H. S. on beech; *Selenia kentaria* Grt. on maple, beech, basswood, and birch; *Abbottana clemataria* G. & A. on maple; *Eufidonia notataria* Wlk., *Macaria bisignata* Wlk., and *Protoboarmia porcelaria* Gn. on pines; *Glena cribrataria* Gn. on spruce; and *Syssaura puber* G. & R. on juniper.

THE TUSSOCK MOTHS

The family Liparidae contains some of the most destructive insects in America, including the gypsy moth and the browntail moth, which were accidentally introduced from Europe. The family is characterized by the body's being clothed with long hairlike scales; antennae (males) highly pectinate. The females, which are often wingless, have anal tufts of hairs for covering their eggs. The proboscis is lacking, and the legs are hairy.

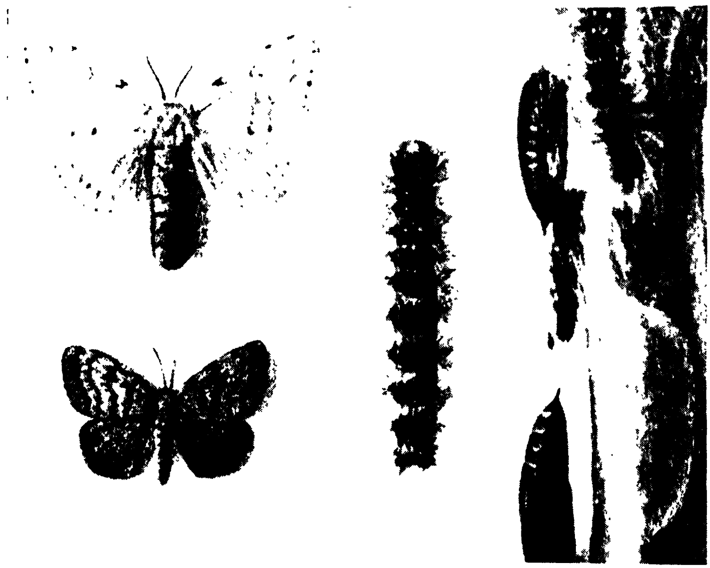

FIG. 151.—Different stages of the gypsy moth, *Porthetria dispar* L. × 1. Adult female above; male; larva; pupae; and egg mass (on twig). *U.S. Dept. Agr. Bur. Entomol. Plant Quar. Howard and Fiske.*)

The gypsy moth, *Porthetria dispar* L. The gypsy moth was brought to America about 1868. Accidentally escaping, it spread gradually in the woodland near Medford, Mass., and becoming acclimated soon developed into a first-class enemy of fruit and shade trees. By 1888 the plague of caterpillars had become notorious, and in 1890 the state began its work against the insect. This work was at first carried on by a commission and later by the State Board of Agriculture and resulted in bringing the pest under control. By 1899 so few moths could be found and so little damage was caused by the insect that the legislature of 1900, not realizing the necessity of continuing control measures, stopped the work. The few moths

left in 1900 multiplied to such an extent that the caterpillar plagues of 1888–1890 are duplicated each summer over a much larger area in eastern Massachusetts.

In July and August the female moths lay their yellow, hair-covered egg masses on the tree trunks, fences, walls, etc. Each egg cluster is about 38 mm. in length by 12 mm. in width and contains about 500 eggs. Hatching takes place in April or May. The young caterpillars first attack the buds and later the blossoms and foliage. Spinning down on silken threads, they are blown about by the wind; or falling on passing vehicles, they are often transported long distances. As they grow, the effects of their feeding become more apparent, and badly infested shade and woodland trees are soon defoliated. By July the caterpillars change to pupae, from which the moths emerge in the course of two weeks to lay eggs for the next year's brood.

Automobiles, electric cars, winds, etc., are the principal means of spreading the moth. The female moths do not fly, and the caterpillars seldom crawl over 200 ft.; but each infested spot, early in the spring, yields a swarm of tiny caterpillars, which by the agencies mentioned spread locally or even to considerable distances, the main spread being, of course, along the principal lines of travel.

The gypsy moth caterpillar is remarkable in that it attacks nearly all common trees. The apple, oak, and willow would seem to be slightly preferred, while the white ash and rock maple are attacked to a lesser extent. Garden vegetables, flowers, and shrubs are consumed as readily as the foliage of fruit trees. Coniferous trees die as a result of one defoliation, while deciduous trees seldom survive stripping three years in succession. Conifers, however, are not a favorite food of the caterpillar, and this fact suggests that woodlands can be made less attractive to them by reducing the oaks and increasing the conifers.

One of the effective methods of reducing the number of this pest, once it has become established in a community, is to destroy the eggs. This is best accomplished by searching out the egg clusters in the fall, winter, or spring and soaking them with a creosote mixture. In applying it a small paintbrush is used, as it is important to soak the clusters thoroughly.

When a loose band of burlap or other cloth is tied about an infested tree trunk, the caterpillars will gather under it in the early morning and may then be destroyed by hand. The burlaps should be examined daily.

Spraying with arsenate of lead at the rate of 10 lb. to 100 gal. of water is very effective. When the caterpillars are small, half that amount of poison is sufficient.

In woodlands infested by this moth it is usually desirable to thin out the trees and cut the underbrush. The brush so obtained should be burned before the caterpillars have hatched. If this work is followed by spraying and burlapping, the moth can be brought under control.

Several professional foresters now make a business of destroying the moths on private estates. Where property owners do not have the necessary appliances, the services of such experts can usually be obtained at a moderate expense.

While the gypsy moth is a serious enemy of trees, it has its own foes in the predaceous insects, parasites, and birds. Several ground beetles prey on the caterpillars, while true parasitic insects attack eggs, larvae, and pupae. Several species of birds, notably vireos and cuckoos, consume large numbers of the caterpillars, while others, like the chewink, chickadee, blue jay, and crow, do their part in reducing the numbers of the pest. The European calosoma beetle, *Calosoma sycophanta* L., has been imported to prey upon the moth, and a pair of these beetles with their progeny have been found to destroy over 6,000 gypsy-moth caterpillars in a single season.

The browntail moth, *Nygmia phaeorrhoea* Don. (*Euproctis chrysorrhoea* L.)—The browntail moth was introduced into Massachusetts in the late nineties, probably from Holland, and is now found over the greater part of New England and in some of the Canadian provinces.

The eggs are spherical, yellow in color, and are deposited in clusters on the undersurface of leaves. Each cluster contains from 200 to 400 eggs, which are covered with the reddish-brown hairs from the body of the moth.

When full-grown the caterpillar is reddish brown in color. Beginning with the fourth, each segment bears a pair of white tufts on each side. On the ninth and tenth segment are small red tubercles bearing poisonous hairs. The length is 32 to 38 mm.

The pupae are generally clustered in folded leaves and fastened with loose silk.

The moth is pure white with the end of the abdomen covered with reddish-brown hairs, which gives it the popular name of the browntail moth. The female is larger and heavier than the male. The former has a wing expanse of about 38 mm. and the latter one of 32 mm.

Winter is passed as a young caterpillar in the silken web of the winter nest. When the warm days of April come the caterpillars leave the nest to feed on the buds, later feeding upon the foliage, becoming full-grown in June. When mature each caterpillar pulls together a few leaves, fastens them with silken threads, and pupates within the enclosure. More than one pupa may be found in a bunch

of leaves. The cocoon stage lasts from two to three weeks, and the moths appear in late July. Eggs are deposited very soon, and the moths perish.

Fruit trees seem to be the first choice, but when the caterpillars become numerous they feed readily upon shade and forest trees (except conifers), as well as on bushes and other vegetation. Over eighty host plants are recorded for this species.

There are numerous parasites of the moths in all stages. Besides the imported ones, several of the native parasites have adapted themselves to the various stages of the intruder.

The principal control measures are removing the nests in winter and spraying the foliage in summer. After the leaves have fallen, the nests are conspicuous and may be removed with a tree pruner. A specially constructed long-handled pruning apparatus is needed for tall shade trees so that the high-hung nests may be clipped off. All nests must be burned.

Arsenate-of-lead spray is sometimes used against this moth, but owing to the habit that the caterpillars have of eating the foliage as rapidly as it appears and thus leaving little surface upon which the poison spray can stick, spraying is not always effective.

Control measures mentioned above are for use on orchard and shade trees but are not adapted to forests on account of the excessive cost. In the forests it is necessary to depend upon the natural enemies for control.

The satin moth, *Stilpnotia salicis* L., family Lymantriidae, is a pure-white moth with a wing spread of from 38 to 50 mm.; introduced from Europe only a few years ago and now firmly established in British Columbia, Oregon, and Washington on the Pacific Coast and in Massachusetts in the east.

The life cycle is quite similar to that of the browntail moth to which it is closely related. The caterpillar is 50 mm. long, black with conspicuous white splotches on the sides. It feeds mainly on poplars and willows.

The white-marked tussock moth, *Hemerocampa leucostigma* S. & A., is one of the most destructive leaf-eating insects in the East and Middle West. The caterpillars become so numerous at times as completely to defoliate elm, maple, linden, horse-chestnut, and birch trees. It is also known to feed to some extent on more than a dozen other broadleaf species.

The eggs are deposited in masses, each mass being about 25 mm. long, oval, frothy, and white. They are placed on tree trunks and large branches, under fence rails and eaves of houses, and in other sheltered places.

The caterpillar is hairy, bright yellow in general color, and striped with black. The head is red, and there are two tufts of long, black hairs rising from the back near the head and a single tuft near the rear end of the body. There are also four cream-colored, brushlike tufts of hair on the back. The caterpillar is about 38 mm. long when grown.

The adult female moth is wingless or nearly so, with thick, oblong oval body, light gray in color, legs long.

The male has well-developed wings, ashy gray in color, with dark, wavy bands across the forewings, a small black spot on the outer edge near the tip, and a minute white crescent near the hind angle. The wing spread is about 32 mm.

FIG. 152.—Western tussock moth *Hemerocampa vetusta* Bdv. Male above, wingless female below. × 2.

FIG. 153.—Larva of western tussock moth, *Hemerocampa vetusta* Bdv., × 1, and (above) the cocoon with egg mass on it.

There are two generations each year in most localities.

The winter is passed in the egg stage; the young larvae emerge from the eggs early in June. They feed on the tender tissue of the leaf at first but later devour the whole leaf with the exception of the heavy veins. When full-grown the caterpillars often travel from tree to tree. They pupate in a grayish cocoon on the trunk.

Parasitism runs very high, often 75 to 85 per cent, but even this high percentage does not seem to hold the pest in check. Birds destroy quantities of the caterpillars but not enough to reduce the number materially. Artificial control should be carried out along two lines: First, destroy the egg masses in winter, and band uninfested trees in the spring; second, spray infested trees in summer. Egg

masses may be scraped off and burned, or they may be destroyed by applying crude creosote by means of a brush or sponge.

In banding uninfested trees, apply a coat of tree tanglefoot around the trunk. The band should be about 10 in. wide. Bands of cotton batting or burlap tied around the tree and turned down in such a manner that the caterpillars will crawl into them serve to turn them away. Spraying with Paris green or lead arsenate is effective but expensive, and the other methods are to be preferred.

FIG. 154. Egg mass of the fir tussock moth, *Hemerocampata pseudotsugata* McDun., deposited on old cocoons.

The western tussock moth, *Hemerocampa vetusta* Bdv.—The female moth is wingless, light gray, body length 16 mm.; the male has a wing expanse of 25 mm. or less and is brown and gray in color. This species occurs from British Columbia to southern California. The caterpillar is 13 to 25 mm. long, grayish with spots of red, yellow, and blue. There are four median and one posterior dorsal white tufts and two anterior and one posterior long black tufts or pencils of hairs. The caterpillars feed on the leaves of oak and willow and also on fruit trees and shrubs.

The oak tussock moth, *H. gulosa* H. Edw.—This species is closely related to the foregoing, but the males are larger and have

more distinct markings on the wings, and the dorsal tufts are black tipped; the tuft on the eighth segment is black. These caterpillars feed on oaks in the Sierras in California.

The fir tussock moth, *H. pseudotsugata* McDun.—The caterpillars of this species have the median tufts tipped with brown and the posterior tuft black tipped with brown. The female is wingless. The caterpillars are common on Douglas fir in British Columbia and have killed large areas of it in northeastern Washington, Idaho, Oregon, and Nevada.

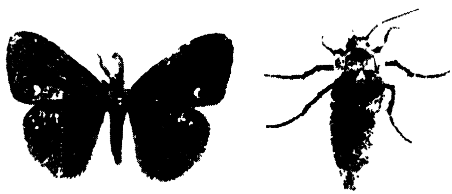

FIG. 155.—Antique tussock moth, *Notolophus antiqua* L. × 1.25. Male, right; female, left.

Oslar's tussock moth, *H. oslari* Barnes.—Similar to the other species of tussock moths. The caterpillars feed commonly high up in the true firs (*Abies*) in the Rocky Mountains and the Sierra Nevadas. They often destroy the seed crop.

FIG. 156.—Larvae of antique tussock moth, *Notolophus antiqua* L. Somewhat reduced (*Photo by Slingerland.*)

The antique tussock moth, *Notolophus antiqua* L.—This is a well-known pest of fruit trees, but it also attacks poplar, alder, willow, beech, birch, oak, and occasionally coniferous trees. It is widely distributed from the Atlantic to the Pacific in the United States and Canada.

THE SPHINX OR HAWK MOTHS

The moths of this group, family Sphingidae, are large and often beautifully colored. They are more or less familiar to all. They are often seen hovering like hummingbirds over the flowers in the evening, where they are dipping deep into the nectar cups of such flowers as the honeysuckle or petunia.

The outstanding characteristics of the adults are the long, pointed forewings; small hind wings; tapering, spindle-shaped body; and very long proboscis which is coiled when not in use.

The caterpillars are naked, usually green, and bear a conspicuous sharp-pointed horn on the back of the eighth abdominal segment; this horn is sometimes replaced by a button-like tubercle. The caterpillars are voracious feeders; when mature they enter the soil to pupate.

The catalpa sphinx, *Ceratomia catalpae* Bois.—The adult is a large, heavy-bodied moth, with strong, narrow, brownish-gray wings having obscure lines and spots of black.

The eggs are laid in masses on the leaves, sometimes as many as a thousand in a single mass, and the young, on hatching, feed in companies for a short time.

The full-grown caterpillar has a broad, velvety-black stripe on the back; the yellow sides are spotted with black; while the underside of the body is greenish. When full-grown it is from 60 to 75 mm. long, with a hornlike appendage projecting from the back of the eighth abdominal segment.

The caterpillars are voracious feeders and will strip a catalpa tree in a very short time. When full-grown they leave the tree to pupate in the ground.

The range is from Illinois to New Jersey and south.

Parasites play an important part in keeping this moth under control, *Apanteles congregatus* (Say) and *Microplitis catalpae* Riley being the most important.

If discovered early when the larvae are still feeding in companies, the infested leaf may be cut off and destroyed. Control may be had at any time by spraying with arsenate of lead or Paris green. Application of arsenical dust by airplanes has proved very effective in the control of these caterpillars. Houser (1922) was the first to demonstrate the practicability of this method of controlling insects on trees.

Many other sphinx larvae attack deciduous trees such as ash, willow beech, elm poplar, and linden. Some of these are restricted in their distribution; others are found more or less commonly from the

Atlantic to the Pacific Coast. They are rarely of much economic importance.

Abbot's pine sphinx, *Lapara coniferarum* S. & A., and the **pine-tree sphinx,** *L. bombycoides* Walk., are the only two species recorded as attacking conifers. These are sometimes very abundant on pines and range as far west as the Mississippi Valley.

Giant Silkworms

The moths belonging to the family Saturniidae are very large and have heavy, hairy bodies. The antennae of the male are broadly pectinate; of the female, much less so. The wings often have transparent or semitransparent spots devoid of scales.

The larvae are mostly naked caterpillars which feed on foliage. They are of large size, usually greenish in color, and generally have large spines or tubercles. Ordinarily, they transform to pupa and adult in a silken cocoon which hangs exposed or partially concealed in a rolled-up leaf, but some species pupate under the soil in a leather-like puparium.

Although there are about thirty-five species in this family, many of which feed on the foliage of forest trees, they seldom become numerous enough to do any very extensive damage; however, a few epidemic infestations have occurred.

The Pandora moth, *Coloradia pandora* Blake.—The adult moth is brownish gray; antennae yellow; thorax clothed with short, soft hairs. Abdomen dark brown above, sides grayish, apex tufted, extending beyond the wings. Wings semitransparent. Forewings with two indistinct, oblique, wavy, brownish bands; a small, distinct black spot on the discal nervure. Hind wings with an indistinct cloudy band, broader at the interior margin. A pale, brownish spot on the disc. Base of wings clothed with pale, pinkish hairs. Underside brownish gray, tinged with pink, the discal spots more distinct than on upper surface. Length 30 mm.; expanse, female, 85 mm.; male, 67 mm.

The larva, when first hatched, is hairy, black or brownish, with a black head. The full-grown larva measures over 50 mm. in length and is greenish in color.

The pupae vary from 28 to 36 mm. in length and are of a purplish-brown to black color. Pupation takes place under the soil at a depth of 1 to 5 in.

Eggs are deposited over a period of 10 to 20 days during July, and the young larvae emerge three or four weeks later. The caterpillars leave the egg by gnawing a hole in one end. The young caterpillars crawl to the new foliage and feed until fall. Winter is

passed as partially grown larvae. Activity starts with warm weather in the spring; at this time the caterpillars are voracious feeders and, if numerous, soon defoliate the trees. By the first week in July they are full-grown and migrate to the ground where they enter the loose

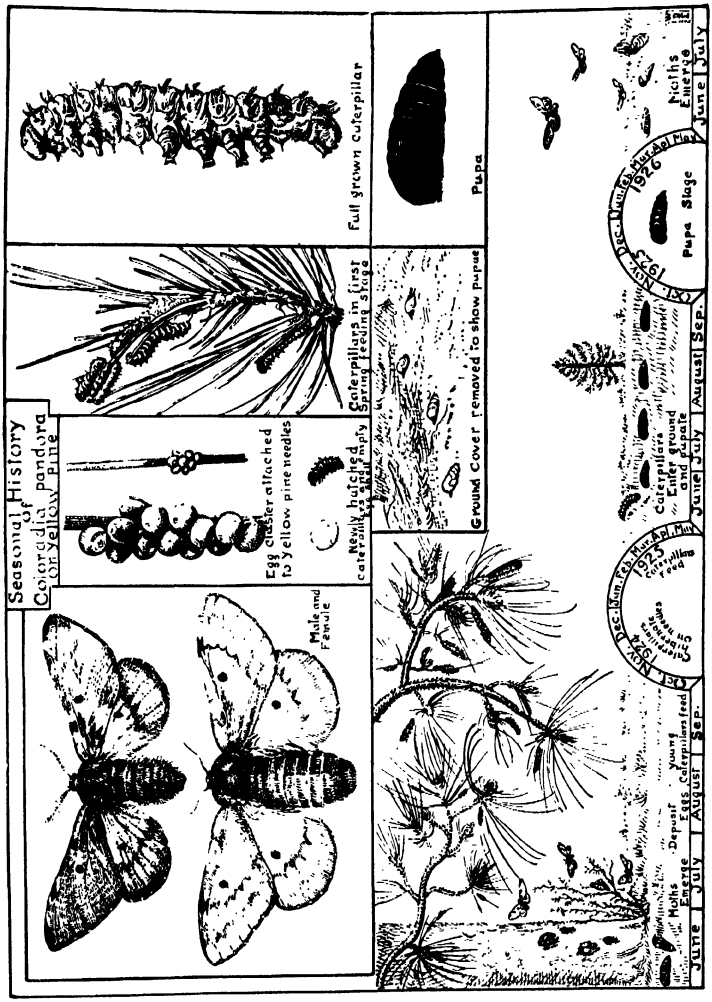

FIG. 157.—Different stages and life history of the Pandora moth, *Coloradia pandora* Blake. Moth, larva, and pupa one-half natural size. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Edmonston.*)

soil to a depth of 1 to 5 in. and pupate. The second winter is spent as pupae, the moths emerging in late June or early July, two years after the eggs were laid. This is the only species belonging to the Saturniidae which is known to have a two-year life cycle.

At intervals of several years this species appears in vast numbers, but, owing to the two-year life cycle, the caterpillars are destructive

only in alternate years, so that trees, even when badly damaged, have an opportunity to recover. Nevertheless, a severe setback occurs, as the tree is stripped when it should be getting its best growth and when it needs its maximum needle surface to protect it from heat and drought. There is always the added hazard of bark beetles entering the area to prey upon the devitalized trees.

In 1918 this moth appeared in small numbers on the Klamath Indian Reservation. During the succeeding five years it spread rapidly, in spite of its natural enemies, until it defoliated the ponderosa

FIG. 158. -Defoliation of ponderosa pine by the larvae of the pandora moth, *Coloradia pandora* Blake. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Photo by Patterson.*)

pine over many square miles extending from the Sprague River to the Upper Klamath marsh.

Fortunately, this species has many enemies. At the time when the full-grown larvae descend to pupate, a large percentage are infected with a disease which causes the body to turn black and shrivel up to one-third its normal size. Examination of large numbers of pupae showed that many of these were also attacked by a disease that caused the insect to disintegrate into a yellowish, watery mass. Squirrels dig up and devour large numbers of the pupae. Some of these are eaten at the time they are dug up, but many are stored for winter food. In addition to the foregoing enemies, a tachinid parasite *Blepharipeza adjusta* Loew destroys about 20 per cent of the pupae.

The caterpillars would undoubtedly succumb to any of the ordinary poison sprays, but the cost of applying such sprays to forest trees

would be prohibitive. The experiments carried out against the catalpa sphinx, using the airplane to scatter poison dust, offers some possibility for a solution.

This moth has been found in limited numbers throughout the Rocky Mountains and Pacific Coast regions, but so far it has appeared in large numbers only in restricted localities. In seeking an explanation for this latter fact, it has been suggested that pupation can take place successfully only when there is a loose, pumice soil into which the caterpillars can dig.

Ponderosa pine, *P. ponderosa*, is the preferred host. Lodgepole pine, *P. contorta*, is also attacked.

The larvae of several other large, conspicuous moths belonging to this family are found feeding on deciduous trees. Only rarely are they of much economic importance. Among the most common of these may be listed Glover's silk moth, *Samia gloveri* Stre.; Cecropia moth, *S. cecropia* L.; luna moth, *Tropea luna* L.; maia moth, *Hemileuca maia* Dru.; Polyphemus moth, *Telea polyphemus* Cram.; and Promethea moth, *Callosamia promethea* Dru.

THE TENT CATERPILLARS

This is a small family, Lasiocampidae, composed of a few widely distributed and well-known larvae of the tent-caterpillar type. The moths are robust, hairy, and of medium-large size. Only one species, the larch lappet, occurs on conifers.

The forest tent caterpillar, *Malacosoma disstria* Hubn.—The caterpillars feed on practically all broadleaf trees but are especially destructive to oaks and maples. In the New England states during the years 1895–1900 there were extensive outbreaks where large areas of the native trees were defoliated and killed. Serious outbreaks occur at six- or seven-year intervals in the Pacific Northwest.

The full-grown caterpillar is about 40 mm. long, brownish in color, conspicuously marked with a series of whitish spots down the middle of the back. There are two bluish lines, edged with brown, on the dorsal surface. The caterpillars do not spin large silken tents but have a habit of gathering in masses when not feeding or when about to molt.

The eggs are deposited in bands around the twigs and are coated with a weatherproof varnish-like substance.

Winter is passed as eggs, which hatch early in the spring. The larvae feed on the leaves until May, when they pupate in cocoons which they have spun in the clusters of leaves. The moths appear in late June and July.

FIG. 159.—Adults of forest tent caterpillar, *Malacosoma disstria* Hubn. × 1. (*Photo by Slingerland.*)

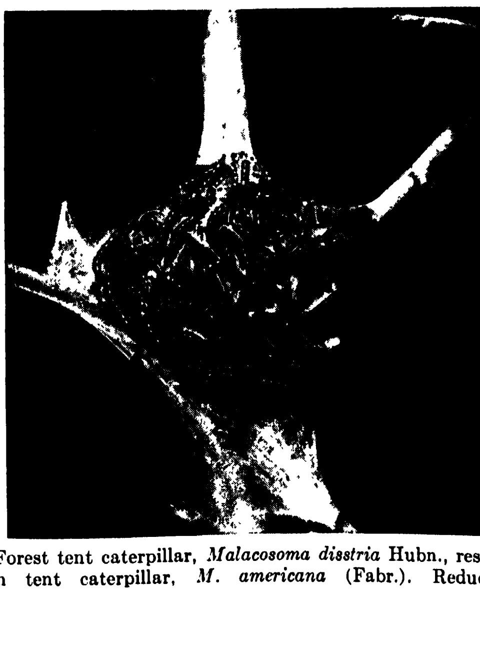

FIG. 160.—Forest tent caterpillar, *Malacosoma disstria* Hubn., resting on the nest of the eastern tent caterpillar, *M. americana* (Fabr.). Reduced. (*Photo by Slingerland.*)

The adult is brownish yellow in color with a wing expanse of 25 to 30 mm. The forewings are marked by two dark lines crossing them obliquely.

Control consists of destroying the egg clusters by clipping off the twigs in the winter and burning them; also by banding the trees and spraying with arsenicals.

The eastern tent caterpillar, *M. americana* (Fabr.), sometimes attacks deciduous forest and shade trees, especially Rosacea. The larvae have a white dorsal line bordered

FIG. 161.—Adult of eastern tent caterpillar, *Malacosoma americana* (Fabr.), resting on cocoon. Natural size. (*Photo by Slingerland.*)

FIG. 162.—Eastern tent caterpillar, *Malacosoma americana* (Fabr.). (*Photo by Slingerland.*)

with reddish brown. They construct large silken webs in which they rest when not feeding.

The California tent caterpillar, *M. californica* Pack.—This is a common oak feeding species found in California. It is similar in habits to *M. americana*. The reddish-brown caterpillar has a narrow blue stripe down the sides. Aside from oak they feed on madrone, poplar, ash, willow and other trees and shrubs.

The western tent caterpillar, *M. pluvialis* Dyar.—This species is similar to the last, but the caterpillars have a row of blue spots down the back, flanked on either side by a row of orange spots. The species is a general feeder and with *M. disstria* becomes sufficiently numerous to cause epidemics over considerable areas in Oregon about every

seventh year, with red alder the preferred host. Ordinarily it is kept in check by tachinid parasites. It ranges from British Columbia to California.

The Great Basin tent caterpillar *M. fragilis* (Stretch), every few years defoliates much of the chaparral in northeastern California, killing it and causing thereby a dangerous fire hazard. It occurs from the Cascade-Sierra Nevada Mountains into the Rocky mountains. *M. constricta* (Stretch) feeds on oak, poplar, ash, and willow in Oregon, California, and Arizona.

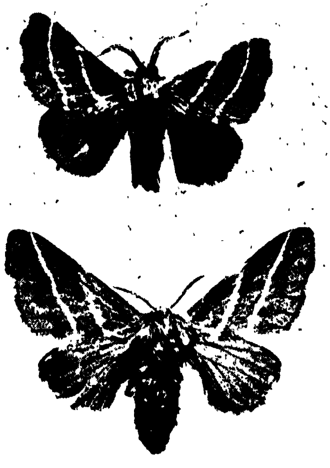

FIG. 163.—Adults of the California tent caterpillar *Malacosoma californica* Pack. × 1. Male above, female below.

The American lappet, *Epicnaptera americana* Harr., is a widely distributed representative of the group of moths whose larvae are remarkable for having on each side of each segment a little lappet or flat lobe from which many long hairs are given out, forming a fringe to the body. The larvae of this species are more than 50 mm. long when full-grown. The upper side is slate-gray, mottled with black, with a transverse scarlet band on the second and third thoracic segments. The moths are found on oak, birch, maple, ash, apple, and cherry.

The larch lappet, *Tolype laricis* Fitch, occurs on the larch in the East. The brownish larva is about 38 mm. in length.

The velleda lappet, *T. velleda* Stoll., feeds on poplar, apple, and other trees. The larvae are bluish gray with faint longitudinal lines. Across the back of the last thoracic segment is a narrow velvet-black band.

The Noctuids or Owlet Moths

The family Noctuidae contains more species than any other family of Lepidoptera in the United States. More than 2,500 species occur within our limits. Most of these moths are night fliers, and many are attracted by lights. There are great differences in size and appearance, but most of the moths are medium-sized and dull-colored. The caterpillars are nearly all naked, but the members of some groups are hairy.

Many of them are general feeders attacking all kinds of vegetation. The larvae of some species may sometimes become abundant enough to destroy every green thing in the district where they occur. They may then migrate in great armies to near-by fields and thus destroy practically all vegetation over many square miles. Other species are more restricted in their feeding habits. No attempt will be made even to list the hundreds of species that have been reported as feeding on various shade and forest trees, as they seldom become of much

FIG. 164.—California tent caterpillars, *Malacosoma californica* Pack., feeding on leaves of live oak.

economic importance. Very few attack conifers. Representation of only a few of the many subfamilies may be mentioned.

The underwings, *Catocala* spp.—The genus *Catocala* Schr. includes many of our largest and most conspicuous noctuids. The prevailing colors of the upper wings are grayish, mottled with lighter and darker spots, making them most inconspicuous when they are resting with wings folded on the trunks of trees. The underwings are, however, beautifully marked with bright red or yellow or brown.

The larvae feed on the foliage of various forest trees. Oak and hickory are hosts for many species. The caterpillars as well as the adults are protectively colored and are very hard to detect when they are resting on the bark of the tree.

The dagger moths, *Apatela* spp.—To the genus *Apatela* belong more than seventy-five species of moths which vary in size and appearance in both the adult and the larval stages. Many of the adults have a more or less dagger-like mark near the anal angle of the forewing. Some of the larvae are naked like most of the noctuids, but others are hairy and look more like arctiids.

The American dagger, *A. americana* Harr., is one of the largest species, having a wing spread of about 56 mm. The forewings are light gray marked with darker spots and wavy lines. The underwings are brownish. The larvae are covered with yellow hairs. There are a few long, black tufts or pencils of hairs scattered over the body. The moths feed on maple, elm, and other forest trees.

The cottonwood dagger, *A. populi* Riley, is a common and widely distributed species. The larva is covered with long yellow hairs with scattered black pencils. It feeds on various species of poplar.

The white pine tufted caterpillar, *Panthea furcilla* Pack., is another hairy caterpillar found feeding on pines late in the summer throughout the Northeastern states.

The ash noctuid, *Homoncocnemis fortis picina* Grt., completely defoliates the ash trees at intervals. In 1931 the ash over considerable areas in southern Oregon were completely stripped of their leaves.

The larvae of *Ufeus plicatus* Pack. feed in the bark of poplar trees from Montana to Oregon.

Cutworms.—Some of the cutworms, of which there are hundreds of species, have a habit of climbing trees and shrubs and eating the foliage. Others sometimes occur in such numbers that they destroy all of the green vegetation in their district, and they will migrate in great armies eating every green leaf; they are then called army worms.

The zebra caterpillar, *Ceramica picta* Harr., is usually dark colored with yellow and white stripes on the side. It is a general feeder and is often found on forest and shade trees. It is widely distributed.

The Tiger Moths

The term tiger moth comes from the fact that the adults, family Arctiidae, are usually spotted or striped. The moths are stout-bodied, medium in size.

The caterpillars are covered with hairs; in many cases clusters of hairs will be longer than others, forming tufts not unlike those on the tussock moths. A number of species feed on forest trees, and besides doing considerable damage by defoliating, they spin extensive webs which may enclose whole branches, giving the tree an unsightly appearance. The hairs of the caterpillars are barbed and when they come in contact with the skin cause an irritation; if rubbed into the

skin a severe rash may develop, similar to that resulting from some of the tussock-moth caterpillars and from the hairs of the browntail moth.

The fall webworms, *Hyphantria textor* Harr and *H. cunea* Dur.—The fall webworm is one of the common caterpillars which makes a large, conspicuous web or tent in late summer or early fall. Unlike the tent caterpillars, the webworms inclose leaves upon which they feed, under their web.

These species feed upon almost any shade, fruit, or ornamental tree, except conifers. While growing the caterpillars do not wander from the web but enlarge it to include fresh leaves upon which to feed. When almost full-grown they scatter, feeding upon anything green; and when abundant they become very destructive at this stage. They are about 25 mm. long when full-grown, pale yellow, grayish, or blue-black in color. The body is covered with long, straight hairs, which rise in tufts from the black or orange tubercles scattered over each segment. They go to the ground to pupate, making a flimsy cocoon of silk and the hair from their bodies. This cocoon is under the debris or slightly under the soil. Winter is passed as a brown pupa within the cocoon.

The moths emerge in May or June to deposit their clusters of several hundred eggs on the underside of leaves near the end of the branches.

The adult moth is usually pure white; occasionally spotted with black.

Two or more broods per year occur in the South, but only one in the northern part of their range which extends from Canada to the Gulf and from Nova Scotia to California.

The most effective method of control is to destroy the web with its brood of caterpillars by cutting them from the tree and burning or by burning them on the tree by means of a torch. In cases where the webs are very numerous or in high trees out of reach for burning, control may be had by spraying with lead arsenate.

The hickory tussock moth, *Halisidota caryae* Harr.—This species does considerable damage to hickory, elm, ash, birch, and basswood throughout eastern Canada.

The caterpillars are black and white, very hairy, and the hairs are arranged in tufts; a line of black hairs runs down the center of the back, and two pairs of long, black, pencil-like tufts are located on the first and seventh abdominal segments. When full-grown the caterpillar is 38 mm. long.

While young the larvae feed gregariously, often stripping the entire tree. They gather in bunches under the leaves at night and leave a trail of silken threads wherever they go. The hairs are particularly

obnoxious, since the barbs with which they are covered produce a painful irritation when they come in contact with the skin. The sores once started have a tendency to spread and persist for some time.

The adult moth is very similar to the silver-spotted halisidota, being slightly larger and the front wings a little lighter. It occurs throughout southeastern Canada, the northern Atlantic Coast regions, and westward into the Mississippi Valley.

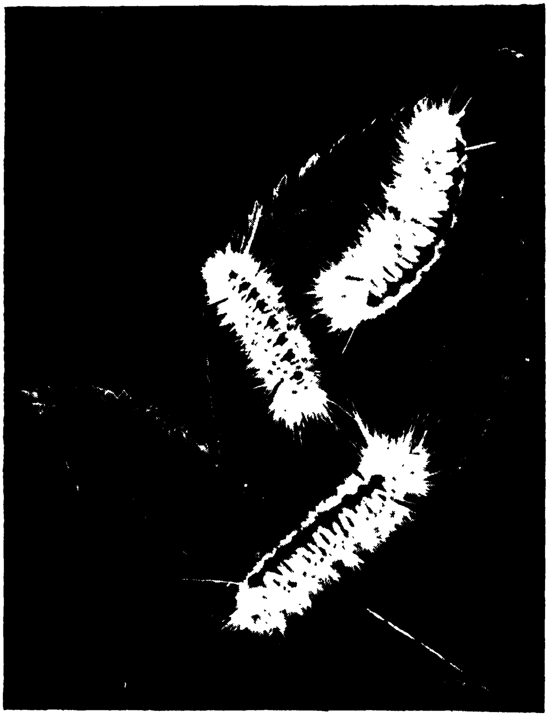

FIG. 165.—Larvae of hickory tussock moth, *Halisidota caryae* Harr. Natural size. (*Photo by Slingerland.*)

A poison spray applied when the caterpillar first appears helps to control this pest.

The silver-spotted halisidota, *Halisidota argentata* Pack.—The adult moth has a wing spread of about 38 to 50 mm., the forewings are brown (darker in the female) with numerous distinct white dots, the hind wings are white, with irregular brown spots near the apex, the body is hairy.

The eggs are deposited in masses and hatch in the fall; the young caterpillars are gregarious until late the following spring. Little feeding is done until warm spring weather, when the feeding mass of caterpillars will strip most of the needles from a branch and cover it

with an unsightly web. When two-thirds grown the caterpillars spread and feed singly until mature, when they descend and pupate on the trunk or in the rubbish of the forest floor. Pupation takes place within a dirty-brown cocoon formed of spun thread and hairs from the body. Pupation occurs early in June, and the adults emerge a month later.

This species ranges from the Atlantic to the Pacific Coast states, the form on the Pacific Coast being a slightly larger variety. The western form, were it not for its natural enemies, would no doubt cause very extensive losses, as it often occurs in vast numbers and not only devours much of the foliage of its host trees but spreads a mass of webs around which detract from the appearance of ornamentals. The barbed hairs are poisonous, as with the hickory halisidota.

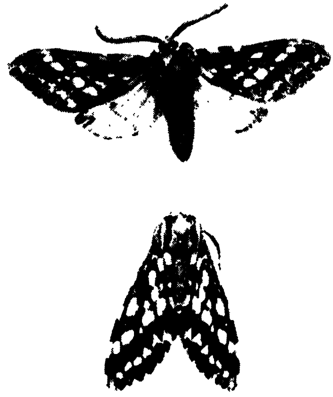

FIG. 166.—The silver-spotted halisidota, the adult of the Douglas fir web worm, *Halisidota argentata* Pack. × 1. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Photo by Miller.*)

Under present conditions applied control is unnecessary. Every four to six years the caterpillars appear in considerable numbers, but

FIG. 167.—Cocoons of the silver-spotted halisidota, *Halisidota argentata* Pack.

two species of Tachinidae, *Pseudeuantha* (*Macquartia*) *pristis* Walk. and *Uramyia halisidotae* Ths., parasitize regularly 90 per cent or more of the caterpillars.

The preferred host is Douglas fir, but the true firs of the genus *Abies* are attacked as well as Sitka spruce and lodgepole and Monterey pine, and occasional colonies have been noted on various species of western cedars.

The pale tussock moth, *Halisidota tessellaris* S. and A.—This species is a general feeder on broadleaf trees but prefers sycamore. It is found from the Atlantic Coast to the Mississippi Valley.

The spotted tussock moth, *H. maculata* Harr.—This is a buff-colored species with spotted forewings, quite similar to *argentata*. It is distributed quite generally throughout the United States and Canada where it feeds upon oak, elm, hickory, beech, locust, willow, and other trees.

Halisidota ingens Hy. Edw. infests ponderosa pine in Colorado.

The Royal Moths

A small family of large moths, the family Citheroniidae, is characterized by soft, rich colors, such as brown, rose, light purple, and yellow. The body is soft and hairy; the antennae of the male are plumose on the basal half only.

The regal moth or hickory horned devil, *Citheronia regalis* Fab.—The moth is of a rich-brown color on body and hind wings; the forewings are slaty gray with yellow blotches and veins broadly marked out in red brown. The wing expanse is about 12.5 cm.

The caterpillar, when grown, measures from 10 to 14 cm. in length. It is yellowish brown, reddish brown, or greenish with whitish and darker spots and lines. It is distinguished from all other caterpillars by the ferocious, though harmless, horns on the thoracic segments.

It feeds on leaves of butternut, walnut, ash, pines, and other trees.

C. sepulchralis G. & R. also feeds on pines.

The imperial moth, *Basilona imperialis* Dru.—This species is as large as the regal moth, of a rich-yellow ground color, hind wings bordered and spotted with brownish purple. The full-grown caterpillar is about 75 mm. long, brown or greenish in color, clothed with long, whitish hairs, and bearing conspicuous spiny horns on the second and third thoracic segments.

Many conifers as well as deciduous forest trees are attacked by this species. It has been recorded from pine, spruce, junipers and hemlock, oak, elm, maple, and hickory.

Pupation takes place in the ground where the rough, brown chrysalids pass the winter.

The green-striped maple worm, *Anisota rubicunda* Fab.—The adult moth is pale yellow, shaded with pink, the pink color predominating in the eastern species, while the yellow with slight rose markings

is characteristic of the more western forms. The female measures 43 to 50 mm. across the spread wings; her body is yellow and woolly in appearance.

The pale-greenish eggs are flattened and deposited in masses.

The caterpillar is naked, nearly 50 mm. long when grown, repulsive in appearance, being pale yellowish green with longitudinal stripes of dark green.

The pupa is very dark brown, armed with little spines on the margin of the abdominal segments and on the thorax; the anal segment ends in a forked projection.

This species is common in the East and Middle West, being quite injurious in the Mississippi Valley from Illinois to the Gulf. It is also extremely injurious in Kansas, New Jersey, and West Virginia.

The various species of maple seem to be preferred, but the caterpillars feed on box elder and certain oaks in the absence of maples.

Birds destroy large quantities of the caterpillars and a few of the moths each year. A number of parasites prey upon the caterpillars.

Spraying with either Paris green or arsenate of lead when the caterpillars are young is the most effective means of control. One pound of Paris green is used to 50 gal. of water. Arsenate of lead should be used at the rate of 2 to 4 lb. to 50 gal. of water.

Trenching has been recommended. The trench should be 1 ft. deep with straight walls at least on the side next to the trees. They may be dug around individual trees or around blocks of trees. The caterpillars will trap themselves in these ditches where they are easily destroyed.

The brown anisota, *Anisota virginensis* Dru.—The adult is brown with a white spot on each wing. The caterpillar is brown, peppered with yellow.

This insect occurs on oak and chestnut in the eastern United States and as far west as Minnesota and Missouri.

The orange-striped oakworm, *A. senatoria* A. & S., occurs in Northeastern states, extending into Canada, on oak, hickory, maple, chestnut, and birch.

The spiny oakworm, *A. stigma* Fab., feeds on oak.

THE SNOUT MOTHS

Perhaps the most important member of this group, family Pyralididae, from the forester's viewpoint is the Zimmerman pine moth which is discussed in the section dealing with the insects in the trunk of the trees. Some species such as the following are defoliators.

The walnut case bearer, *Mineola juglandis* LeBar.—The larvae feed upon the leaves of walnut and hickory. The common name is

derived from the caterpillar's habit of drawing two leaves together and building a silken case between them. In the autumn before the leaves fall the larva moves its case to a twig where it is securely fastened. Here the winter is passed. In the spring the case is loosened, and the caterpillar moves about feeding upon the new foliage. Later transformation to pupa takes place. In the early summer an inconspicuous gray moth with a wing spread of about 18 mm. will emerge.

To the genus *Acrobasis* belong numerous species most of which are leaf or bud feeders. Many of them are widely distributed. *A. angusella* Grote., *A. stigmella* Dyar, *A. caryivorella* Rag., *A. caryae* Grote., *A. kearfottella* Dyar and *A. latifasciella* Dyar all attack hickory. *A. demotella* Grote., and *A. palliolella* Rag. feed on walnut. *A. hebescella* Hulst. folds the leaves of oak; and *A. betulella* Hulst. is found on birch.

Tetralopha asperatella Clem. is widely distributed. The larva is greenish granulated with yellow and feeds on oak, maple, elm, and beech. *T. militella* Zell. occurs on sycamore; and *T. robustella* Zell. on pine in the eastern states.

The basswood leaf roller, *Pantograpta limata* G. & R.—This species is easily recognized by its work. The bright-green caterpillars cut the leaves of the host nearly across and roll the distal portion into a tube. When grown they leave this nest, spin a cocoon in a fold of the leaf, and pass the winter as caterpillars, pupating the following spring. The adult appears in midsummer as a moth yellowish in ground color with dull-green and purplish markings. It is widely distributed.

The walnut girdler, *Euzophera aglaeella* Rag., mines in the cambium of the native black walnut in the western states. It may completely girdle the trees.

Herculia phoezalis Dyar attacks the cypress in southern California, sometimes being quite abundant.

The Oak Moth

The family Dioptidae is represented in the United States by only a single species, which preys upon the various oaks of middle and southern California.

The California oak moth, *Phryganidia californica* Pack.—These moths are of a light-brown color with prominent dark veins. The body is about 12 mm. long; the wings have an expanse of 32 mm. The males may be distinguished by the broader and more feathery antennae.

The caterpillar when full grown is about 25 mm. long, black, and nearly hairless. The chrysalis varies from whitish to yellow in color and is marked with black lines and spots.

The young caterpillars begin to feed upon the leaves, selecting the soft portions of the upper leaf surface. For a time the larvae remain in groups, but later they scatter and feed on the edges of the leaves, devouring all but the midrib and larger veins.

When mature the caterpillar migrates to a sheltered spot to pupate. After remaining about two weeks in the chrysalis the moths emerge and mate, and the female deposits her eggs. There are two generations each year.

FIG. 168.—Adult and pupae of California oak moth, *Phryganidia californica* Pack., × 1.25, on trunk of live oak tree.

This insect occurs throughout central and southern California. The principal host is the live oak, *Quercus agrifolia,* but the valley oak, *Q. lobata,* is a common host, and a few other trees may occasionally be attacked.

The oak moth larva has many natural enemies including a bacterial disease. These are usually abundant enough effectively to control the pest, but at intervals of every five or six years the caterpillars become destructively abundant.

The young caterpillars may be controlled by an arsenate of lead spray.

THE PROMINENTS

These are medium- to large-size moths, family Notodontidae, with heavy bodies usually well-clothed with hairs; the legs also have long hairs.

FIG. 169.—Work of early stages of the California oak moth, *Phryganidia californica* Pack.

FIG. 170.—Larvae of California oak moth, *Phryganidia californica* Pack., killed by bacteria. × 1.

The caterpillars feed upon the leaves of trees or shrubs and may be either naked or clothed with hairs. Spines, tubercles, or prominent outgrowth is usually found on the larvae.

The caterpillars spin a frail cocoon within which they pupate. Some species occasionally become quite injurious locally, but they are of no more than secondary importance as forest pests.

The red-humped caterpillar, *Schizura concinna* S. & A.—The adults of this insect are reddish brown or gray. The larval head and

FIG. 171.—The red-humped caterpillar, *Schizura concinna* S. and A. About natural size. (*Photo by Slingerland.*)

a prominent hump are coral red. They feed on poplar, willow, and birch as well as fruit trees in all parts of the United States and southern Canada.

The unicorn caterpillar, *S. unicornis* S. & A.—The larva of this species is characterized by a large, conical tubercle on the first abdominal segment. This bears, at its tip, two smaller slender, spreading, cylindrical tubercles. It feeds on a number of different plants including oak, elm, and hickory. It is widely distributed throughout the East.

The larva of *S. ipomoae* Dbl. has the tubercle on the first abdominal segment very large and high, ending in a deep fork each tine of which bears a stiff, truncated spine. Less conspicuous tubercles occur on other abdominal segments. This species is widely distributed in the eastern states and is found on oak, maple, and some other trees.

S. leptinoides Grt. feeds on oak, walnut, etc.; *S. semirufescens* Wlk., on maple and other trees.

The walnut caterpillar, *Datana integerrima* G. & R.—The larvae attack black and English walnut, oaks, beech, hickory, willow, and locust. They are distributed from Maine to Florida and west to Kansas, at times completely defoliating walnut and butternut trees over wide areas.

The caterpillars of the various species of *Datana* are marked with conspicuous colors—reds, yellows, and white—and their characteristic habit of elevating the head and anal end of the body will help to identify them.

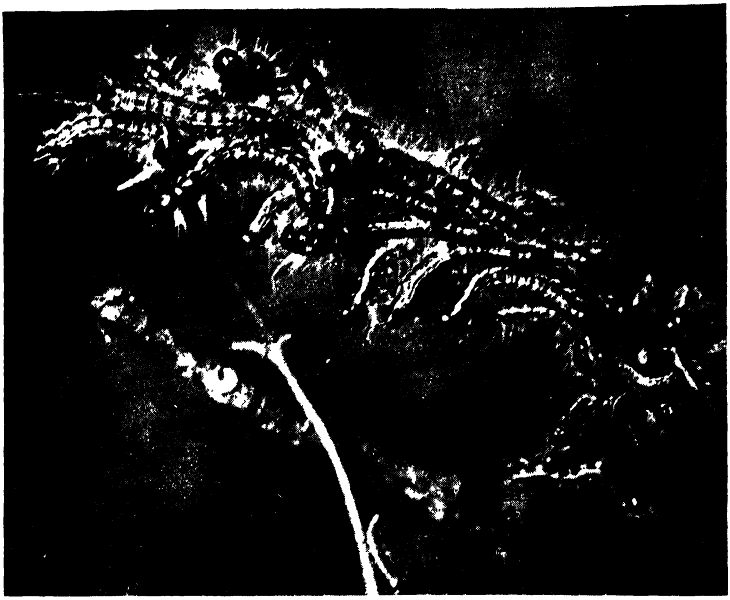

FIG. 172.—The walnut caterpillar, *Datana integerrima* G. and R., massed together on a hickory limb which they have defoliated. × 1.

The yellow-necked caterpillar, *D. ministra* Wlk., is black with long, whitish hairs and four yellow stripes on each side. It is about 50 mm. long when grown. It is generally distributed throughout the states east of the Rocky Mountains and less commonly on the Pacific Coast. It feeds on oak, chestnut, walnut, hickory, beech, and birch. The larvae are gregarious and may be found in great masses on the leaves of their host plants.

D. angusii G. & R. is reported from walnut and hickory; and *D contracta* Wlk. from oak, chestnut, and hickory.

The red-humped oak caterpillar, *Symmerista albifrons* A. & S.—The caterpillar is made conspicuous by the large red hump on the

eighth abdominal segment. The adult is an ashy-gray moth with a wing spread of about 50 mm. It occurs from the Atlantic states west to Kansas and feeds on oak, beech, and maple.

The variable oak leaf caterpillar, *Heterocampa manteo* Dbl.—Oaks, basswood, birch, and walnut are sometimes more or less seriously defoliated by this caterpillar which is about 32 mm. long and variable in color, the pattern consisting of brown and greenish with a light stripe down the back. It is widely distributed in the eastern half of the United States.

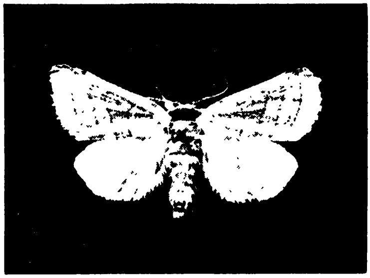

FIG. 173.—Adult of yellow-necked caterpillar, *Datana ministra* Wlk. × 1.

The maple prominent, *H. guttivitta* Wlk.—This caterpillar, which attains a length of 37 mm., is green, marked with yellow and purple. It is sometimes injurious on maple, oak, chestnut, beech, and other trees.

H. biundata Wlk. is common on maple and other trees. *H. obliqua* Pack. and *H. umbrata* Wlk. occur on oak; and *H. bilineata* Pack. on elm.

The green oak caterpillar, *Nadata gibbosa* S. & A.—Oak, maple, and white birch are sometimes attacked by this caterpillar which is about 25 mm. when full-grown. It is greenish with a more or less distinct yellowish lateral line.

The rosy hyparpax, *Hyparpax aurora* S. & A.—The caterpillar of this moth occurs on various species of oak. The red head, the conspicuous pointed elevations on the first and eighth abdominal segments, the brownish and yellowish or pinkish dorsal markings, together with the slender, extended prolegs which are carried elevated in the air, all combine to give this caterpillar a striking appearance. It reaches a length of about 38 mm.

Lophodonta angulosa S. & A. also occurs on oak; *L. ferruginea* Pack., on birch. *Nerice bidentata* Wlk. attacks elm. *Fentonia marthesia* Cr. is found on oak and maple. *Dasylophia anguina* S. & A. attacks locust; and *Misogada unicolor* Pack. lives on sycamore. *Ianassa lignicolor* Wlk. occurs on oak, beech, and birch; and *Hyperaeschra georgica* H.-S. on oak.

The following species have been reported from poplar and willow: *Melalopha apicalis* Wlk., *M. strigosa* Grt., *M. inclusa* Hbn., *M. albosigma* Fitch., *M. brucei* H. Edw., *Hyperaeschra stragula* Grt., *Pheosia dimidiata* H.-S., *Cerura scitiscripta* Wlk., *Harpyia modesta* Hud., and *Gluphisia septentrionalis* Wlk.

The Bagworms

The family Psychidae is composed of curious creatures the caterpillars of which carry their homes with them. The males are winged, but the females are wingless and maggot-like.

Fig. 174. Bags of the bagworm, *Thyridopteryx ephemeraeformis* Haw. in a spruce tree which they have defoliated.

The evergreen bagworm, *Thyridopteryx ephemeraeformis* Haw.—The bagworm or basketworm is found in the Atlantic states and west into the Mississippi River Valley, where the bags, hanging in coniferous, deciduous, and fruit trees, can be seen in the late summer and fall. The bags are soft, spindle-shaped masses covered with pieces of dead leaves bound together by silken threads. In these bags the caterpillar lives and during the feeding stage extends the fore part of the body from its shelter, feeding as it moves about, carrying its bag with it. The bag of the female may reach a length of two nches.

The female moth is wingless and grublike. The wings of the male are not covered with scales but are smooth and transparent somewhat ike a wasp's.

Pupation takes place in the bags, which have been fastened to the twigs of the tree. The males appear in September or October

at which time the female has partially emerged from her case in order that fertilization may take place, after which she withdraws into the case and deposits her eggs. The number of eggs deposited is often very large, over 1,000 having been counted in a single bag.

Control may be had by clipping the bags in winter and burning them or by spraying in the spring with lead arsenate (3 lb. to 100 gal. of water).

Slug Caterpillars

The term slug caterpillars is applied to a group of larvae which in general appearance resemble slugs much more than they do the larvae of most other moths. The caterpillars may be naked or clothed with tufts of hairs or branching spines. Some species are provided with venomous setae. The dense, brownish cocoons are usually found between leaves.

The moths, family Eucleidae, are of small or medium size. The wings are covered with heavy, loose scales.

The saddleback caterpillar, *Sabine stimulea* Clem., is readily recognized by the large, green patch and a smaller oval, purplish-brown spot on the back. It feeds on oaks and other forest trees but is seldom abundant enough to be of any importance. It occurs in the eastern and central states.

The spring oak slug, *Euclea delphinii* Bdv.—This larva is short, stout, with the subdorsal and lateral spines irregularly but about equally developed. It is well-armed with venomous setae. It feeds on oak, willow, and other trees and occurs as far west as the Mississippi Valley.

The hag moth, *Phobetron pithecium* S. & A.—The nine pairs of fleshy, hair-covered appendages which are twisted up and back suggest the disheveled locks of a hag. These processes, which are furnished with fine, stinging hairs, are detached and incorporated in the cocoon when it is spun. These larvae feed on various shrubs in the eastern states.

The wings of the moths belonging to the family, Megalopygidae, are heavily and loosely scaled, and mixed with the scales are long, curly hairs giving the wing the appearance of bits of flannel.

The crinkled flannel moth, *Megalopyge crispata* Pack., is the most common of these. The short, thick larvae are covered with long, silky, brown hairs interspersed with venomous setae. They feed on oak, elm, and other trees along the Atlantic Coast. *M. opercularis* S. & A. is a similar, smaller species with a southern range extending as far west as Texas.

The following species belonging to the family Gelechidae are found in the Eastern states and Canada.

Recurvaria robiniella Fitch feeds on locust. *R. quercivorella* Cham. makes a silken tube on undersides of oak leaves. *R. dorsivittella* Zell. is found on sweet gum.

Dichomeris ligulella Hub. is a common pest on apple but also rolls oak leaves. *D. caryaefoliella* Cham. sews the leaves of hickory together. *D. georgiella* Wlk. is a leaf roller on oak. *D. marginella* Fab., the juniper webworm, lives in a social web on *Juniperus communis*.

Duvita vittella Busck has been found in stunted cones on Scotch and Austrian pines.

Telphusa latifasciella Cham., *T. quinquecristatella* Cham., *T. fuscopunctella* Clem., *T. querciella* Cham., *T. palliderosacella* Cham., and *T. basifasciella* Zell. are all found on oak in the Eastern and Central states. *T. betulella* Busck rolls the leaves of black birch. *T. belangerella* Cham. rolls alder leaves.

Aristotelia fungivorella Clem. and *A. salicifungiella* Cham. feed on willow.

CASE-BEARERS

The term case-bearer is given to members of the family Coleophoridae, although there are species in several other families that form cases and are also entitled to the name.

The majority of the species are leaf miners in the early caterpillar stage and later are case-bearers.

Practically all of the economic species belong to the genus *Coleophora* (*Haloptilia*) which contains almost 100 described forms.

The larch case-bearer, *Coleophora laricella* Hub.—This insect is injurious to the larch forests of Europe. From there it was introduced to England and Scotland, thence to America. It occurs on European larches, particularly *L. europea*, in New York and the New England states and on domestic and exotic larches in eastern Canada, New Brunswick, and Nova Scotia. In 1932 this pest was particularly destructive, defoliating most of the larch from New Brunswick westward into Ontario.

The destruction and shriveling up of the foliage give the tops of the trees a brown color; growth stops; and the trees become weak and subject to disease. Trees ten to forty years old are preferred; this includes the young and vigorous ones, while the old and isolated trees seem to be more resistant.

The insects hibernate in the cases fastened to the twigs. At the time of hibernation they are one-third to one-half grown. The case

consists of a mined larch leaf and is nearly cylindrical. At the time of hibernation the outer end is closed, and the other end attached to the twig. The cocoons may be isolated or in groups of four or five. The winter case is from 3 to 4 mm. long. In the spring the insects go to the buds, taking their cases with them.

The larva eats a hole in the leaf and devours the contents, leaving only the epidermis. The leaf becomes bleached and if deserted turns brown and shriveled. A single larva attacks many leaves in a season. As the larva becomes larger the winter case splits and is sown up with silk; later as more room is needed the larva enlarges the case with bits of leaf and silk.

When full-grown the caterpillar is 5 mm. long, dark reddish brown, with a black head. It pupates in its case. The pupal stage lasts from two to three weeks.

The moth is silver gray-brown. Both pairs of wings are narrow with a fringe of long hairs. Wing expansion is 8 mm. The moths are active during the day. Mating takes place several days after emergence, and a week or ten days later, in early June, the reddish-brown eggs are laid on the surface of the leaf. The young larva bore through the floor of the egg into the leaf and start their mine, and live here until September, when most of them emerge to construct their winter casings which are made of sections of leaves and silk. They continue to feed for three or four weeks after the winter case is constructed, before retiring to hibernate.

Individual trees which are valuable may be protected by applying a winter-strength lime-sulphur spray early in the spring, or arsenate of lead (2 to 4 lb. to 100 gal. of water) will give control. No method of control under forest conditions is feasible at the present time.

The elm case-bearer, *Coleophora limosipennella* Dup.—This species, like the last, has been introduced from Europe. The work is quite characteristic, consisting of rectangular brown areas on the leaves of various elms. These are due to the tiny brown caterpillars' having eaten out the tissue between the upper and lower epidermis. The cases in which the larvae live are brown, flattened, and about 9 to 10 mm. long.

Winter is passed as caterpillars in the cases; in the spring they resume feeding, and the adults appear in July. At present the insect is confined to the North Atlantic and the southern New England states where it is sometimes quite serious locally. Control is the same as for the larch case-bearer.

The hickory case-bearer, *C. caryaefoliella* Clem., is an important enemy of the hickory and pecan throughout the region where these trees occur. The larval case is about 6 mm. long, brown, smooth,

and without serrations on the upper edge. The mouth is deflected to 45 deg. *C. oystryae* Clem. or *Oystrya virginica* may be the same species as the hickory case-bearer. *C. alniella* Hein. feeds on beech in New York. *C. kearfottella* Barnes & Busck forms a larval case of silk and bud scales on willow in New Jersey. *C. lencochrysella* Clem. is common on chestnut throughout its range. The case is irregular, with the silken first case inserted in a later one cut from the mined portion of the leaf. It is 10 to 11 mm. long.

C. tiliaefoliella Clem. makes a uniform black case with the pistil handle turned down abruptly. It occurs on basswood in Ontario and in the eastern United States. *C. atromarginata* Braun. is found on southern red oak and swamp white oak in eastern United States. The larval case is black with faint white V markings on the underside. *C. querciella* Clem. makes a grayish case with a conspicuous black, somewhat humped patch on the back near the posterior end. It is found on white oak and swamp chestnut oak in eastern United States.

The maple case-bearer, *Paraclemensia acerifoliella* Fitch., family Incurvariidae.—The moth has a wing spread of 12 mm.; the thorax and front wings are steel blue, hind wings pale brown, fringed with long hairs. Body dark brown; legs paler. Head with a tuft of bright orange and yellow hairs.

The yellowish-brown pupae are about 4 mm. long and are found in pupal cases consisting of four oval pieces of leaves, two above and two below. This cell is lined with silk, and the edges are fastened together with silk. The pupal cases are found on the ground under the trees, the caterpillars having migrated down the trunk or lowered themselves on silken strands.

The moth is a primitive member of the order and possesses an ovipositor with which the epidermis of the leaf is pierced and the eggs left within the puncture. Many eggs may be deposited in a single leaf, over 100 having been reported.

The larvae mine within the tissue of the leaf for about ten days. Leaving the blotchlike mine, when slightly over 1 mm. long, the caterpillar forms its case which is henceforth carried about with it and enlarged from time to time to accommodate its growing body. Food is procured by consuming the epidermis of the leaf. Although the eggs hatch in early June, it is not until August that the caterpillar is 5 mm. long and full-grown.

This maple case-bearer appears at intervals and is extremely destructive to maples, especially the sugar maple, for a number of years and then disappears only to reappear a number of years later. The duration of the period of activity ranges from 1 to 10 years, and

records indicate that it may be absent from a locality for as long as 40 years. It may occur also on birch, oak, beech, and huckleberry.

The range extends from Ontario to New Jersey west to Illinois.

Burning the leaves will destroy a large proportion of the pupae. The leaf-feeding caterpillars can be readily poisoned by applying lead arsenate (4 lb. to 100 gal. of water) or by dusting.

THE SHIELD-BEARERS

The moths of the family Heliozelidae are of small size, wings lanceolate, legs long, antennae one-half to two-thirds as long as the front wings. The species are readily distinguished from other families by the type of work as exemplified by the typical example cited below.

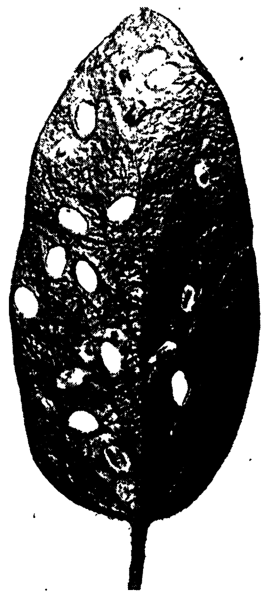

FIG. 175.—Work of the madrone shield-bearer, *Coptodisca arbutiella* Busck. The holes indicate the portion of the leaf that has been cut out to form the case or shield in which the larvae hibernate. Some of the cases containing larvae may be seen on the leaf. $\times$ 1.

The madrone shield-bearer, *Coptodisca arbutiella* Busck, is a minute moth with a wing expanse of about 5 mm. Ground color dark silver gray, apical half of the front wings marked with olive green, gold, and silver and a tiny black patch at the apex. The work of the larvae consists of minute mines in the leaves. When mature they cut out an elliptical portion of the leaf which is carried to the twig or trunk and remains throughout the winter. In some regions the young larvae may pass the winter in the leaves. The adults emerge during the latter half of May (Oregon), and eggs are deposited on the leaves. These are so small as to be seen only under a high-power microscope. At intervals the moths become quite abundant, and madrone tree leaves are so badly infested as to give the tree a general rusty appearance. Several species of parasites have been noted on the leaves at the time of emergence and oviposition. As yet none has been identified, but they undoubtedly serve to check the moths, as epidemics are of very short duration. This species is found throughout the range of its only host, madrone, *Arbutus menziesii*.

Coptodisca lucifluella Clem. lives on hickory. *C. saliciella* Cham. occurs on willow and is reported from Missouri and Washington. *C. juglandiella* Cham. feeds on black walnut.

The sour-gum shield-bearer, *Antispila nyssaefoliella* Clem.—This species works in the leaves of sour-gum trees in the eastern and southern states. Its habits are very similar to those of the madrone shield-bearer.

The aspen shield-bearer, *Antispila* sp., cuts oval sections from the leaves of aspen, *Populus tremuloides,* and other poplars in the northern sections of the Cascade and Rocky Mountains.

LEAF MINERS

Species belonging to the family Gelechiidae are of small size; the front wings are broad and rounded at the tip, while the hind wings are somewhat trapezoidal in shape. The caterpillars of the forest

FIG. 176.—Lodgepole pine needle miner, *Recurvaria milleri* Busck. × 4. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Edmonston.*)

species are leaf miners, leaf rollers, or inhabit cones. The family is a a large one containing over 400 described species from North America exclusive of Mexico.

The pine leaf miner, *Paralechia pinifoliella* Cham., is a very small, grayish-brown moth with a wing expanse of 6 to 8 mm. The larvae mine the leaves of various pines in the northeastern states. They

sometimes become numerous enough to kill an occasional tree. *Arogalea cristifasciella* Cham. feeds on oak in the eastern and central United States.

The lodgepole pine needle miner, *Recurvaria milleri* Busck.—The adult is a small, grayish moth with a wing expanse of about 12 mm. The head, forewings, and thorax are silvery-gray irregularly marked with black; hind wings and face lighter; abdomen white.

FIG. 177.—Lodgepole pine defoliated by needle miners, *Recurvaria milleri* Busck. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Photo by Patterson.*)

Eggs are deposited in the sheath of the needles in July or August. Young larvae emerge in August or September and by October are about 2 mm. long and have mined only a short distance down the first needle. Winter is passed in this first needle. In May of the next year the larvae resume feeding. By August they leave the first needle and enter the second one. At this time they are over one-half grown and work more rapidly. By late October they are practically full-grown and pass the second winter in the second needle. Activity

begins again in May. The second needle is abandoned, and a third needle is entered; the larvae after feeding a short time prepare the tunnels for pupation by lining them with silk.

So far as known this species works only in the needles of lodgepole pine, *Pinus contorta* and the Jeffrey pine, *P. jeffreyi.*

It has been reported from the upper Tuolumne river watershed where it has been very destructive and has been noted on the Deschutes National Forest in Oregon. In California the larval infestations occur only in belts between 7,000 and 9,000 ft.

The insect has ten distinct species of hymenopterous parasites which destroy about 15 per cent of each brood. Certain birds, notably the pine siskin, feed upon the moths during the flight period.

During the two periods of migration when the larvae are going from one needle to another there is probably a great mortality, since the larvae are exposed to all kinds of natural enemies.

Experiments recently made indicate that this insect can be controlled by prompt applications of oil sprays just after the egg-laying period.

The spruce leaf miner, *Recurvaria piceaella* Kearf.—The small, light-grayish moths emerge late in June and soon deposit their eggs on the needles of various conifers. The young larvae hatch and bore a very minute mine, which enlarges as they grow. Later they leave the mined-out needle and enter another. Winter is passed in the caterpillar stage.

This species attacks red and Norway spruce and balsam fir in the northeastern states, while a very similar or identical species attacks blue and Engelmann spruce in the Rocky Mountains.

R. pinella Busck is quite similar to *R. milleri* and attacks ponderosa pine in the Rocky Mountain states.

R. apicitripunctella Clem. builds silk-lined tubes between needles of bald cypress and other trees in the eastern and central states. *R. juniperella* Kear. occurs on *Juniperus* in the eastern states. *R. gibsonella* Kear. also occurs on *Juniperus* in eastern Canada. *R. stanfordia* Keif. attacks cypress in California.

The following species are recorded as leaf miners on the hosts indicated. Most of them are recorded from the eastern and Mississippi valley states:

Gelechia trialbamaculella Cham., oak, locust; *G. bicostomaculella* Cham., oak; *G. maculimarginella* Cham., oak; *G. vernella* Murt., laurel, oak; *G. gilvomaculella* Clem., oak; *G. bimaculella* Cham., red maple, eastern states; *G. pseudoacaciella* Cham., locust; *G. trophella* Busck, oak; *G. dyariella* Busck, cottonwood; *G. versutella* Zell., cottonwood.

The family Nepticulidae includes the smallest of the Lepidoptera, some species having a wing expanse of only 3 mm.

The larvae are mostly leaf miners, many infesting trees. The full-grown caterpillar leaves the leaf, goes to the ground, and spins a dense, flattened cocoon in the litter. The larval gallery is either linear or blotchlike and is constant for the species. The form of the mine and the host plant will usually determine the species.

Members of one genus *Ectoedemia* are numerous and very interesting but of little economic importance. Most of our known species belong to the genus *Nepticula* and are quite fully treated by Braun (1907), who has given figures of some of the mines.

RIBBED CASEMAKERS

The larvae of the members of the family Lyonetiidae are leaf miners or live in webs between the leaves.

The oak ribbed casemaker, *Bucculatrix albertiella* Busck.—The moth has a wing expanse of 8 mm. and is white with faint yellow markings. The larva mine the leaves of live oak in California. After the first molt they feed on the outside of the leaf. The pure-white, ribbed cocoons, which give the species its common name, are often abundant on the oaks. The species becomes numerous enough to do considerable damage at times, often causing partial defoliation.

The birch leaf skeletonizer, *B. canadensisella* Cham., feeds upon the parenchyma of the leaves of birch, often completely skeletonizing them. Alder and oak may be attacked also. The larvae are sluggish and when disturbed drop to the ground by means of a silken thread.

The cocoons are white and ribbed, turning dark with age.

The moth is found throughout northeastern United States and southeastern Canada.

The cottonwood leaf miner, *Proleucoptera albella* Cham.—The adult moth is white with two yellow spots bordered with black near the apical end of the front wings. The wings are long, narrow, and fringed with long, white, scalelike hairs. The female is about 8.2 mm. long. The male is smaller, being 6.4 mm. in length.

The larvae are uniform light yellow, with numerous long hairs scattered over the body. The full-grown caterpillar is from 5 to 7 mm. in length.

The pupa is dark brown, lighter on the dorsum, with a white line extending from the prothorax to the end of the mesothorax.

The caterpillars enter the leaf directly from the egg and mine therein until they are full-grown. At this time all of the leaf, excepting the veins, has been mined. When full-grown the caterpillars eat their way out and pupate under a mass of silk fastened in a curled

leaf; or several leaves are fastened together and the cocoon is spun within this shelter. The fall generation of larvae often drop to the ground or to low brush and spin cocoons in any sheltered places.

This species often becomes numerous and attacks various poplar trees to such an extent as practically to defoliate them.

A minute hymenopterous parasite *Harismenus* sp. is an important enemy, often parasitizing more than 50 per cent of the pupa. Further protection may be obtained by piling and burning the leaves in the fall.

The larvae of *Bucculatrix packardella* Cham. occur on oak, chestnut, and beech. The distribution is general, extending west to California. *B. coronatella* Clem. is found on black birch.

Phyllocnistis liriodendrella Clem. makes a convoluted tract mine with a central frass line in the small terminal leaves of the tulip tree. *P. magnoliella* Cham. occurs on various magnolias. *P. populiella* Cham. forms a brood mine of the shining, snail-track type but with distinct central lines of frass. It feeds on aspen and other poplars. The distribution is general. *P. liquidambarisella* Cham. makes similar mines without the central frass line in sweet-gum leaves.

TRUMPET LEAF MINERS

The larvae of most of the members of the family Tischeriidae are leaf miners. Some of them, like the oak trumpet leaf miner, *Tischeria zelleriella* Clem., make trumpet-shaped mines, but most of those working in oak leaves make blotch mines. The moths have narrow, pointed wings. The anterior margin of the front wings is strongly arched.

T. fuscomarginella Cham. mines on the underside of oak leaves in Kentucky. *T. concolor* Zell. mines at the edge of oak leaves in Texas. *T. castaneaella* Cham. forms a narrow blotch mine along the edge of chestnut leaves in Kentucky and Virginia.

The larvae of *T. tinctoriella* Cham. makes crumpled blotch mines on oak from Quebec to Texas. *T. citrinipennella* Clem. makes similar mines and is reported from New York, Pennsylvania, Ohio, and Missouri.

LEAF BLOTCH MINERS

The forewings of these moths, family Gracilariidae, are long, slender, and pointed; rear wing narrower, often with a more or less prominent expansion on the costal margin near the base. The adults when at rest have a peculiar habit of *elevating the front part of the body, the front legs* being held vertical, and the tips of the wings touching the leaf or other surface. Many are beautifully colored—*yellow, orange, and gold being the most common colors.*

The larvae are always leaf or bark miners when young, often changing their habits when partly grown, forming nests in a folded leaf. The young caterpillars are flat with bladelike mandibles fitted for feeding on the sap of cells. The full-grown larvae are cylindrical and feed in inflated mines or on the surface of the leaf protected by a fold of the leaf which usually takes the shape of a cone.

The genus *Lithocolletis* Hbn. (*Cameraria*) includes more than seventy species many of which mine in leaves of broadleaved forest or shade trees.

White oak leaf miner, *Lithocolletis cincinnatiella* Clem.—This is a minute, dainty moth, measuring a little over 3 mm. in length and 6 mm. across the spread wings. It is grayish in color, with faint, darker bands across the wings.

It sometimes occurs in countless numbers in the oak regions of the North Central states.

The minute, flattened caterpillar or grub mines the leaves of *Quercus alba.* In some cases 80 per cent of the leaves show one to three mines, and each mine contains one to six larvae.

There are two broods, one emerging in July to deposit eggs, larvae from which pupate in a cocoon within the leaf and pass the winter in this pupal stage in leaves on the forest floor. The adults of the first brood emerge in the spring. The larvae attack the new leaves, and adults emerge in July.

The infestation of a large percentage of the leaves weakens the vitality of the trees and renders them more susceptible to attack from other insects. The brown-spotted leaves detract greatly from the appearance of attacked trees.

Many parasites have been bred from the white oak leaf miner.

A large percentage of the overwintering pupae may be destroyed by surface burning, where it is safe to do so, or by raking the fallen leaves into piles and burning.

Braun (1908) gives an interesting synopsis of species of *Lithocolletis* by food plants.

In addition to the species listed by her, some of which occur in the West, the following western species may be mentioned: *L. incanella* Wlshm. and *L. alnicolella* Wlshm. on alder; *L. arbutusella* Braun on madrona; *L. tremuloidiella* Braun on poplar; *L. apicinigrella* Braun on willow. *L. felinella* Hein. sometimes defoliates sycamores. *L. agrifoliella* Braun makes irregular, whitish blotch mines on live oak. *L. mediodorsella* Braun on oak; *L. umbellulariae* Wlshm. on California laurel or bay.

The genus *Gracilaria* Haw. includes a number of species which are found in some forest and shade trees. The larvae of these are flattened

at first but soon become cylindrical. In their early stages they live in blotch mines but later roll a leaf into a conical nest. The following species are mostly eastern in their distribution: *G. acericlla* Cham. is found on walnut. *G. bimaculatella* Ely lives in a leaf that has been rolled into a cone on red and soft maple. *G. packardella* Cham. is generally distributed on sugar maple. *G. purpuriella* Cham. feeds on poplar and willow, rolling the leaf down from the tip. *G. negundella* Cham. mines first on the lower side then on the upper side of the leaves of box elder and finally makes the usual cone. *G. glutinella* Ely and *G. elongella* L. occur on alder. *G. querciniyrella* Ely is found on oak. *G. pulchella* Cham. feeds on yellow birch. *G. reticulata* Braun rolls the leaves of live oaks in California.

In 1926 the garry oak, *Q. garryana*, over an area extending for 40 miles along the central Willamette Valley, was severely defoliated by a species very closely related to *G. elongella* L. *Ornix* (*Paraornix*) *conspicuella* Dietz occurs on black birch, and *O. vicinella* Dietz on yellow birch in Pennsylvania.

Acrocercops strigifinitella Clem. bores first in the lateral veins, then in the midrib, of chinquapin oak and beech leaves. *A. strigosa* Braun attacks swamp-chestnut oak. *A. albinatella* Cham. makes first a linear, then a tentiform, mine in oak.

Parectopa salicifoliella Cham. is a blotch miner in willow. *P. robiniella* Clem. makes a digitate mine on locust.

Marmara salictella Clem. forms a long linear mine under the bark of willow twigs.

LEPIDOPTEROUS LARVAE ATTACKING CONES OR SEEDS

The larvae of many small moths attack and destroy the cones or seeds of a number of our forest trees. These are often of considerable importance, as, when abundant, they distinctly influence the number and kinds of young trees in a region.

Cone pitch moths, genus *Barbara* Hein. (*Evetria*), family Olethreutidae. The larvae feed in the cones of *Abies* and *Pseudotsuga*, forming resinous burrows. None of the species of this genus attacks the buds, stems, bark, or other parts of the tree.

The Douglas fir cone borer, *B. colfaxiana* (Kearf.).—The adult has a wing spread of 15 to 21 mm. and is silvery gray with dark russet-brown transverse stripes on the forewings. The larvae attack the cones of *Pseudotsuga taxifolia* and cause considerable damage to seed crops. Flight occurs early in the spring, and eggs are deposited on protruding bracts of the young cones in May and early June; the young larvae on hatching reach the base of the cone scales by boring

through the bracts. As the larva continues to grow it forms a resinous channel through the interior of the cone and feeds first on the scales and later on the seeds. The cone is not killed immediately as a result of this attack, but heavily infested cones usually wither before they mature. The resinous exudations between the scales often keep them from opening normally and prevent the release of uninjured seeds. Pupae are formed during July and August in cocoons near the axes of the cones. Moths emerge in April and May of the following spring. There is one generation annually, while part of the broods may retard as pupae and pass through a biennial generation.

Barbara ulteriorana (Hein.) also attacks Douglas fir cones and is considered to be an aberrant form of *B. colfaxiana.* Its wing spread is 13 to 14 mm.

The white fir cone moth, *B. colfaxiana siskiyouana* (Kearf.), is a larger and more strikingly marked form which attacks the cones of *Abies concolor, A. shastensis,* and *A. magnifica* in the Pacific Coast region. The wing spread is 21 to 24 mm.

B. colfaxiana taxifoliella (Busck) is a form with a wing spread of 13 to 15 mm., reared from Douglas fir in Montana.

B. colfaxiana coloradensis (Hein.) feeds on *Abies* and *Pseudotsuga* in Colorado.

Spruce cone moth, *Epinotia (Eucosma) hopkinsana* (Kearf.), has a wing spread of 16 to 19 mm. The forewings vary from pale apple to dark green. The larvae are reddish and feed in the cone scales and seeds of *Picea sitchensis.* They have also been found attacking the cambium of twigs and limbs. This species has likewise been reported from *Pinus radiata.*

Epinotia hopkinsana cupressi Hein., considered by some as a distinct species, has a wing spread of 19 to 21 mm. and feeds on the cones and foliage of California cypress and arborvitae.

E. subviridis Hein. also attacks *Cupressus macrocarpa.* The wing spread is 16 to 20 mm.

The alder catkin moth, *E. albangulana* (Wlshm.), has a spread of 10 to 12 mm. The larvae feed in the catkins of *Alnus oregona.*

E. nanana (Treit.) occurs on spruce, the larvae webbing the terminal leaves together.

Ponderosa pine cone moth, *Eucosma bobana* Kearf.—The adult is a tawny moth with a wing spread of 17 to 28 mm. The larvae feed on the scales and seed of growing ponderosa pine and Jeffrey pine cones, causing noticeable frass masses on the surface. The pupae form in silky cocoons between the scales in October, and moths emerge the following June. There is one generation annually.

Lodgepole pine cone moth, *E. rescissoriana* (Hein.).—The larvae feed in cones of *Pinus contorta,* causing a mass of resinous castings to form, which are held to the side of the cone by a silky web. The wing spread is 23 mm.

E. sonomana Kearf. has a wing spread of 18 to 21 mm. The larvae bore in the pith of the terminal branches of *P. ponderosa* and *Picea engelmanni.*

E. monitorana Hein. has a wing spread of 13 to 16 mm. The larvae bore in the cones of pines in Pennsylvania and Virginia.

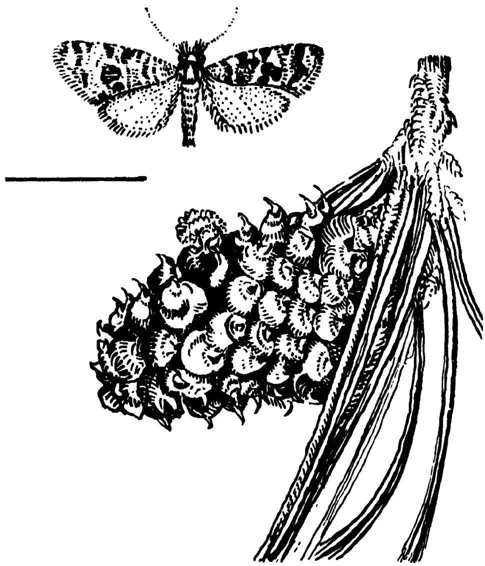

FIG. 178.—Lodgepole pine cone moth, *Eucosma recissoriana* (Hein.). × 1.75. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Edmonston.*)

The maple seed moth, *Proteoteras aesculana* Riley, is a common species occurring in both eastern and western United States. It has a wing spread of 11 to 18 mm. The larvae bore in seeds, leaf stalks, and terminal twigs of horse chestnut and maple.

P. willingana (Kearf.) has a wing spread of 15 to 20 mm. The larvae form galls in the terminal twigs and leaf stems of box elder.

The Douglas fir cone moth, *Zeiraphera diniana* (Guenee) (*Enarmonia pseudotsugana* Kearf.), is a fawn, fuscous, and gray moth with a wing spread of 15 to 21 mm. The larvae infest the cones of Douglas fir in Montana, Oregon, and British Columbia.

Seed and cambium moths, genus *Laspeyresia* Hbn.—This genus contains a large number of species, with a great variety of hosts and feeding habits. The important forest forms are those that attack

the cones and seeds of conifers and the cambium of limbs and twigs. Some species work in the cambium of broadleaf trees.

The ponderosa pine seed moth, *Laspeyresia piperana* (Kearf.)—The adult is olive brown with metallic-bronze transverse bands across the forewings; spread 19 to 20 mm. The eggs are deposited on the outer surface of scales soon after the cone starts its second year of growth. The larvae bore into the axis of the cone and extend tunnels

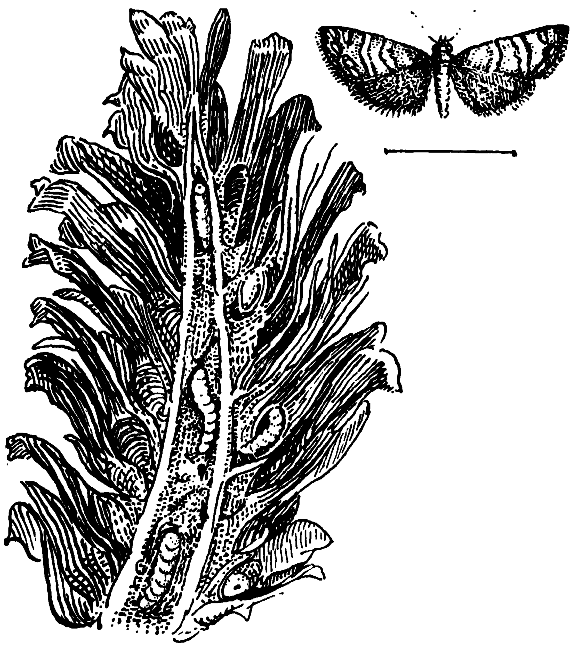

FIG. 179.—The ponderosa pine seed moth, *Laspeyresia piperana* (Kearf.). × 1.75. Larvae in center of cone and in seeds. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Edmonston.*)

through the pith; from these they bore into the seeds on which they feed. The larval burrows are lined with a silky web which connects the mined seeds with the axis and prevents release of these seeds after the cone opens. The pupae form during the fall and winter in the larval galleries in the pith and seeds. The moths emerge in the spring. There is one annual generation, but a part of the larvae retard and remain in the dry cones until the second spring.

L. toreuta (Grote) is very similar to *L. piperana* and is found in the eastern states, District of Columbia to North Carolina, where it attacks the cones of *Pinus virginiana*.

L. erotella (Hein.) is found on *Pinus taeda* in the Southeast and *P. attenuata* in the West. The larvae live in pitch nodules or galls.

The fir seed moth, *L. bracteatana* (Fernald), has a wing spread of 9 to 14 mm. The larvae feed in the scales and seeds of *Abies concolor* in California and Oregon and form pupae in silky cocoons between the scales or in the soil. Also reported from Douglas fir and bristle-cone fir in the West.

The spruce seed moth, *L. youngana* (Kearf.), has a wing spread of 8 to 11 mm. The larvae attack the cones of *Picea alba, P. sitchensis,* and *P. pungens,* boring tortuous food burrows near the axis and destroying both scales and seeds. The larvae enter the axis of the cone as it matures and pupate in the pith.

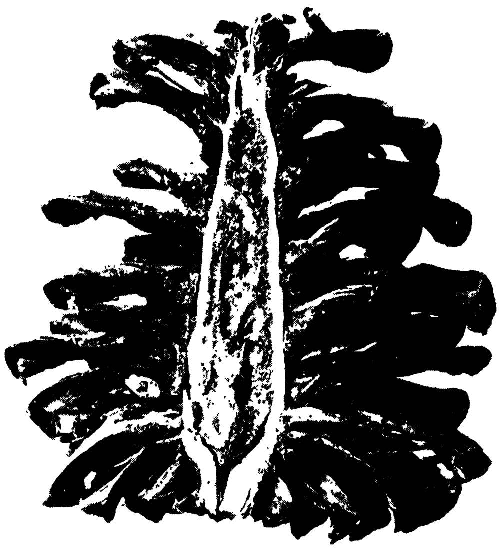

FIG. 180. Work of the Jeffrey pine seed moth, *Hedulia injectiva* Hein., in Jeffrey pine cone.

The cypress cone moth, *L. cupressana* (Kearf.), is dark, smoky brown with greenish-yellow and copper markings and a spread of 14 to 16 mm. The larvae are white and feed in the green cone clusters of *Cupressus macrocarpa* and *C. sargenti;* they also attack the cambium of the trunk and limbs, particularly in the forks, and cause pitch exudations mixed with castings.

L. populana Busck has a spread of 11 to 14 mm. The larvae mine the cambium of *Populus trichocarpa* in Montana.

The Jeffrey pine seed moth, *Hedulia injectiva* Hein., has a spread of 16 to 20 mm. It is similar in appearance to *L. piperana* (Kearf.) but is a larger form which attacks most commonly the cones of *Pinus jeffreyi.*

The acorn moth, *Melissopus latiferreanus* (Wlshm.), is reddish brown, with a spread of 11 to 20 mm. The larvae mine in acorns of various oaks, beechnuts, and chestnut burrs in the Pacific Coast and

FIG. 181. - Knobcone pine cones infested by pine cone moth *Dioryctria xanthoenobares* Dyar. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Photo by Patterson.*)

eastern states. They have been noted to emerge and pupate in a cocoon formed from a leaf and a circular piece cut from another leaf. There are two generations in some sections. A similar if not identical species is found rarely in the acorns of Garry oak in Oregon and California.

Pine cone moth, *Dioryctria xanthoenobares* Dyar, family Pyralidae, is a small, reddish-tan moth the larva of which attacks the young cones of ponderosa pine, *Pinus ponderosa*, and knobcone pine, *P. attenuata*, throughout Montana, Colorado, Oregon, and northern California.

FIG. 182.—The cone pyrallid, *Dioryctria abietella* D. and S., natural size, and work in cone. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Edmonston.*)

The creamy-white eggs are deposited on the surface of cone scales and on twigs during July and August. The young caterpillars excavate long, tortuous food galleries in the young cones and ultimately destroy the seeds. The following June the caterpillars pupate in separately lined cells in or on the surface of the cone, the adults emerging during July and August, one year after the eggs were deposited.

Infestations totaling 50 per cent of the cones in certain areas in Colorado have been reported.

The cone pyralid, *Dioryctria abietella* D. & S., is a silvery-gray moth with dark bands across the forewings which spread 25 to 30 mm. The larvae are found in the cones of firs, pines, and hemlocks. The pupae are formed in silky cocoons in the soil and are usually imbedded in a mass of sand particles. The species is widely distributed in this country and occurs also in Europe.

D. reniculella Grote is very much like *D. abietella* in appearance and habits. It attacks spruce throughout the eastern states.

FIG. 183.—Work of the cone pyralid, *Dioryctria abietella* D. and S., in cones of *Abies magnifica*. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Photo by Keen.*)

Monterey cypress commophila, *Commophila macrocarpana* (Walshm.), family Phalonidae.—The large, greenish larvae extend galleries through scales of cones of *Cupressus macrocarpa*, destroying part of the seed crop. They spin a web over the feeding galleries to which the frass adheres. They are also cambium feeders in the twigs.

Sitka spruce commophila, *Commophila fuscodorsana* (Kearf.).—The larvae bore irregular food burrows through the cones of Sitka spruce, destroying scales and seeds.

The cone tineid, *Holcocera augusti* Hein., family Blastobasidae.—The larvae feed in cones of *Pseudotsuga taxifolia* and are often associated with the infestation of the Douglas fir cone moth in the western states. It may be predaceous. *H. confluentella* Dietz is found on pitch pine in the East.

Valentinia glanduella (Riley).—The larvae feed in the acorns of *Quercus californica* and are associated in feeding habits with the acorn weevil.

The oak coccid blastobasid, *Zenodochium coccivorella* Cham., is predaceous in the coccid genus *Kermes* in Florida.

The fir cone geometrid, *Eucymatoge spermaphaga* Dyar.—The larvae bore large galleries through the cones of *Abies concolor, A. shastensis,* and *P. taxifolia,* destroying both seeds and scales in Oregon and California. It has also been reared from the cones of spruce in Maine.

Several species belonging to the genus *Gelechia,* family Gelechiidae, have been reared from cones. *G. periculella* Busck is a small black moth the larvae of which occur in the mature cones of *Pinus ponderosa* and *Pseudotsuga taxifolia* in Oregon and California.

MOTH LARVAE ATTACKING THE TWIGS

The twigs, particularly the new growth, of many conifers are often attacked by the larvae of small moths which bore into and thus destroy them. The members of the family Olethreutidae are among the most destructive members of this group. The adults have a fringe of long hairs on the upper side of the hind wing near the base.

The pine tip moths, genus *Rhyacionia* Hub. (*Evetria*).– Larvae feed only on pines, boring into the buds and from them into the new growth of the stems. Their presence is usually indicated by a resinous exudation about the buds; but none of them causes pitch nodules to form on the stems.

The Nantucket tip moth, *Rhyacionia frustrana* (Comst.).—This species occurs nearly everywhere in pine regions east of the Rocky Mountains. The adult has a wing spread of 9 to 15 mm. The larvae attack all species of pines except white pines. Two generations are produced annually. This moth is of considerable economic importance. It is sometimes destructive to Forest Service plantations.

The western pine tip moth, *R. frustrana* var. *bushnelli* (Busck) is a western species which has caused a great deal of damage in nurseries and plantations of pine. Its favorite host appears to be *Pinus ponderosa,* but it attacks many other species. This is recognized as the form that was introduced into the pine plantations of the Nebraska National Forest at Halsey, where it became a serious pest.

The adult has a spread of 9 to 15 mm., the front wings being rusty with markings of light and dark gray. There are two generations annually. The first flight occurs early in the spring, and eggs are deposited singly on the tips, needles, and buds in April and May. The larvae attack the growing buds and shoots, forming a burrow over which they spin a protecting web. Pupae of this generation are formed inside the feeding burrow during June and early July. Adults from these pupae start to emerge the last of June, and flight continues

well into July. The larvae of this summer generation feed on the new terminals until they pupate during the latter part of August. The summer generation does not pupate in the feeding burrows, but the larvae drop to the ground and spin a cocoon in the soil, where they overwinter as pupae. No practical control methods have been developed except hand picking and destroying the infested tips.

The lodgepole pine tip moth, *R. montana* (Busck).—The larvae destroy the terminal buds of *Pinus contorta* in Montana. It has a wing spread of 19 mm.

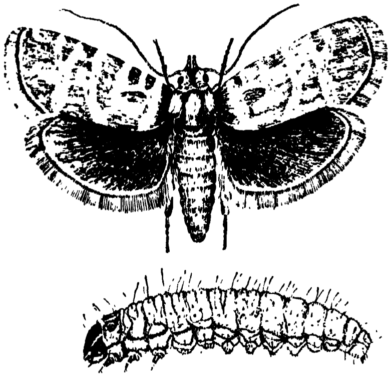

FIG. 184.—The European pine shoot moth, *Rhyacionia bouliana* (Schiff.), and larva. × 3. (*After Carmody in U.S. Dept. Agr. Bul.* 170.)

FIG. 185.—The lodgepole pine twig moth, *Petrova metallica* (Busck) × 1.5, and pitch nodule on twig caused by the work of the larva. Upper left, the pitch has been removed to show the larva in the twig. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Edmonston.*)

The Monterey pine tip moth, *R. pasadenana* (Kearf.), is reddish and silvery gray, with a wing spread of 14 to 17 mm.; the larvae infest the terminals of the branches of *Pinus radiata* and other pines along the coast of California. It is also found on ponderosa pine of the Sierra Nevada. One generation occurs annually.

The southwestern pine tip moth, *R. neomexicana* (Dyar), is of great economic importance in New Mexico and Arizona where it attacks the new shoots of *Pinus scopulorum*. There is one generation annually. The larvae leave the twigs about July 15 and enter the ground where they pupate and overwinter. The wing spread is 19 to 28 mm.

R. rigidana (Fern.) is an eastern form, with a wing spread of 19 mm. The larvae attack the tips of *Pinus virginiana, P. taeda,* and *P. sylvestris* in the Atlantic states.

The European pine shoot moth, *R. bouliana* (Schiff.), was introduced into this country about 1914 and has become established along the Atlantic Coast and in the Central states. The larvae attack the new shoots of many species of pine, often destroying all of the new growth. It is very destructive in nurseries. An arsenical or nicotine spray applied two or three times in late June and early July is reported to help prevent infestation.

Pitch nodule moths, genus *Petrova* Hein.—The larvae bore into the stems, branches, and bark of pines and spruces, some species

FIG. 186.—Pitch nodules on twigs of lodgepole pine caused by the larvae of the lodgepole pine twig moth, *Petrova metallica* (Busck).

favoring the new and others the older growth. None of them attacks the buds. All cause a characteristic nodule of pitch and frass which forms over the part of the tree attacked, in which they pupate.

The lodgepole pine twig moth, *Petrova metallica* (Busck).—The adult is purplish brown with metallic scales, the thorax white dusted with grayish fuscous; the wing spread is 16 to 19 mm. The larvae attack the twigs of *Pinus ponderosa* and *P. contorta* in Montana, Oregon, and California, causing a pitch nodule to form on the stem. In lodgepole pine this injury usually kills the twig beyond the nodule. In the high elevations of the Sierra Nevada region there is a two-year life cycle.

The digger pine twig moth, *Petrova sabiniana* (Kearf.), is a strikingly colored orange yellow and white species which forms pitch nodules on the twigs of *Pinus sabiniana* in California. The wing spread is 17 to 23 mm.

The single-leaf pine pitch moth, *Petrova monophylliana* (Kearf.), infests the branches of *Pinus monophylla* in the Sierra Nevada Mountains and in Nevada. The wing spread is 15 to 19 mm.

Petrova edemoidana (Dyar) has been reared from *Pinus ponderosa* in Arizona. The wing spread is 19 to 20.5 mm. *Petrova luculentana* (Hein.) works in *Pinus ponderosa* in Colorado. The wing spread is 16 to 17 mm.

The spruce pitch moth, *Petrova burkeana* (Kearf.), attacks *Picea sitchensis* and *Picea engelmanni* in Washington and Montana. The larvae feed in pitchy scars. The adults are whitish with gray markings and have a wing spread of 26 to 28 mm.

Petrova (*Eucosma*) *picicolana* (Dyar) attacks *Abies lasiocarpa* and *A. grandis*. The wing spread is 27 to 52 mm.

The pitch twig moth, *P. comstockiana* (Fernald), a common eastern form, has a wing spread of 14 to 20 mm. The larvae form nodules on the new twig growth of *Pinus taeda, P. rigida,* and *P. sylvestris*. *P. virginiana* (Busck) has a wing spread of 17 to 23 mm. The larvae normally attack the older twigs and branches of *Pinus virginiana.*

Laspeyresia inopiosa Hein. has a wing spread of 9 to 11 mm. The larvae feed in the twigs of *Pinus contorta* in Idaho.

The Monterey bud moth, *Exoteleia burkei* Keif.—The larva of this moth bores out a central longitudinal gallery in developing buds of Monterey pine in the early spring, causing the young shoots to droop and die. The adult is a small, dark, grayish-brown moth, with three whitish transverse fasciae, edged by black tufts, and bright orange coloring between their fasciae.

The family Yponomeutidae includes several tiny moths with comparatively broad wings. The caterpillars mine in twigs or leaves of conifers or broadleaved trees. Rarely are they of more than minor importance.

The cypress twig miner, *Argyresthia cupressella* Wlshm., is a small, golden-colored moth with dark markings on the wings. The caterpillars mine and kill the twigs of cypress, cedar, redwood, and juniper in California. *A. franciscella* Busck is a very similar species attacking Monterey cypress.

The cypress twig moth, *A. trifasciae* Braun, also attacks the Monterey cypress.

A libocedrella Busck.—This species greatly resembles the foregoing. It measures about 8 mm. across the spread wings. The caterpillars

work in Lawson's cypress, *Chamaecyparis lawsoniana,* and incense cedar, *Libocedrus decurrens,* in Oregon. *A. arceuthobiella* Busck also infests incense cedar in the same region.

A. pilatella Braun works in Torrey pine, *Pinus torryana,* and Monterey pine in California.

Busck reports *A. pygmaeella* Hbn. and other species as working on willow, birch, and alder in British Columbia.

A. goedartella (L.) infests the terminals and catkins of birch and alder in western states.

The following eastern species are recorded:

A. freyella Wlshm. on cedar and arborvitae; *A. subreticulata* Wlshm. on basswood; *A. alternatella* Kearf. on juniper berries; *A. thuiella* Pck. on arborvitae.

The European pine leaf miner, *Ocnerostoma pinariella* Zell., is reported from New York.

White cedar twig borer, *Recurvaria thujaella* Kearf., family Gelechiidae.—Severe injury has been suffered by white cedar, both the cultivated and the wild trees, in northeastern United States and southeastern Canada from the ravages of this moth.

The minute caterpillars bore into the tips of young twigs, killing them, and the result is a devitalized and ragged-looking tree. When full-grown the larva is about 7 mm. long, slender, dull red, with the anal end black, head black and shining.

The moth is silvery white with black and brown markings. Pupation takes place in a tiny white cocoon in the twig.

Winter is passed as caterpillars, each in a mine in the twig. The adults appear, often in great numbers, in June.

There are two important hymenopterous parasites: a tiny blue chalcid *Closterocerus trifasciatus* West and *Pentacnemus bucculatricis* How.

Dioryctria cambiicola Dyar, family Pyralidae, works in terminal branches of ponderosa pine where it produces large swellings and knotty growths. It is widely distributed.

MOTH LARVAE ATTACKING THE TRUNKS

Three families of moths include species the larvae of which do more or less injury by feeding under the bark or in the solid wood of various trees.

The Clear-winged Moths

The moths of this group, family Aegeriidae (Sesiidae), may be recognized by narrow, more or less transparent wings and by the fanlike tufts at the end of the body, especially noticeable in the

males. The caterpillars being internal feeders are mostly white without markings, head rounded, and body somewhat flattened.

Their work often results in the death of the host or in serious defects which appear in the course of lumbering.

The Douglas fir pitch moth, *Synanthedon novaroensis* Hy Edw. – The adults are strikingly beautiful, wasplike moths with orange-red bodies marked with steel-blue bands. They are day fliers and move very swiftly, hence are seldom seen.

In some sections the Douglas-fir pitch moth, according to Brunner, is one of the greatest factors in reducing the profit of the millman handling Douglas fir. This moth is the primary cause of a very large

Fig. 187.—Larva of Douglas fir pitch moth, *Synanthedon novaroensis* Hy. Edw. × 1.5.

percentage of the pitch seams, pitch pockets, and gum checks in what would otherwise be absolutely clear lumber. It is estimated that the ordinary loss to Douglas fir from pitch seams, pitch pockets, etc., in the Rocky Mountains is from 7 to 15 per cent of the cut.

The eggs of the moth are oblong, brownish, and deposited singly in the edges of wounds or on a smooth piece of bark; each female deposits about thirty eggs and often in as many different trees. In about two weeks the eggs hatch into a tiny, transparent white larva. One year is required for this larva to develop in western Oregon. Brunner states that three years are required in Montana. When full-grown it is from 25 to 40 mm. long and slightly more opaque than during its early stages of life.

The majority of the moths emerge from June 15 to July 15, and the adult lives only a few days after emergence.

The young larvae may be located by the exudations from the mine which penetrates through the bark to the cambium. Toward the end of the season a pitch tube covers the wound and the larvae.

Douglas fir, *Pseudotsuga taxifolia*, is the favorite host of this moth, but it will attack weakened larch, *Larix occidentalis;* Austrian pine, *Pinus austriaca*, is also severely attacked. In selecting its host trees, this moth seems to prefer the healthy and faster-growing firs where there is plenty of shade. Young stands are most susceptible to injury. Older trees have roughened and thick bark which renders them immune, except where old wounds invite reinfestation.

In Oregon two parasites, a tachinid *Nemoraea* (*Xanthopyta*) *labis* (Coq.) and *Pyracmon* sp., an ichneumon, are common, and fully 50 per cent of the caterpillars are killed each year.

The sequoia pitch moth, *Vespamima sequoiae* Hy. Edw.—The adult moth is lemon yellow with black markings and very much resembles a wasp. It measures about 25 to 30 mm. in wing spread.

It ranges through the northern Rocky Mountain and Pacific Coast states and is reported quite injurious in British Columbia.

Almost all the conifers within its range may be attacked. Lodgepole pine is preferred in the Rocky Mountain states while Douglas fir is attacked in considerable quantities in western Oregon and

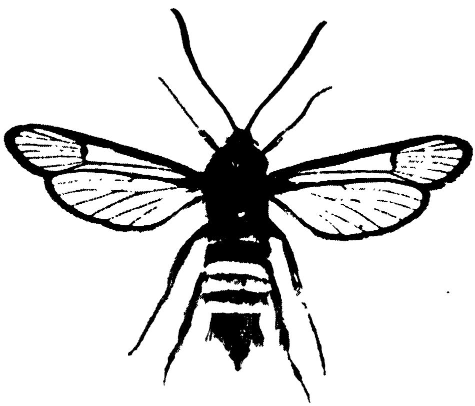

FIG. 188.—The sequoia pitch moth, *Vespamima sequoiae* Hy. Edw. × 2.

Washington. Ponderosa pine, Monterey pine, and redwood, *Sequoia sempervirens*, in California and ponderosa pine and lodgepole pine in eastern Washington and Oregon are the most common hosts. In contrast to the Douglas-fir pitch moth, this species seems to prefer open stands and dry, sunny slopes, avoiding shade. The female deposits her eggs from the middle of June until Aug. 1, depending on weather and altitude. The adult lives only a few days (three to five) but during this time is very active depositing eggs. Eight days after the eggs are deposited the larvae appear, and each excavates a tunnel into the cambium. Two years are spent in the larval stage, and near the end of the second year the larva hollows out a chamber in the pitch and lines it with silken threads, hardly substantial enough to be called a cocoon. In this it pupates late in May or in June. Thirty days are spent in the pupal stage.

The larva penetrates to the cambium and makes a cross gallery, causing the pitch to flow very freely. During the two seasons the larva is developing it keeps the wood from growing over its tunnel, and consequently at the time of emergence the tunnel is deep in the sapwood. Trees of all sizes from 1 in. up to 2 ft. or more in diameter are attacked.

The larvae are seldom directly responsible for the death of a tree, but with their tunnels cutting off from 25 to 50 per cent of the circumference of the tree it is easy to see that growth is checked and the tree weakened; the large quantity of pitch issuing from near the base of the trees increases the fire hazard.

Parharmonia pini Kell. attacks pine in eastern Canada and northeastern United States. Eggs are deposited, and the caterpillars usually enter below a limb or on the border of old wounds. Two to three years is required for the complete life cycle.

Parharmonia picea Dyar is reported in Sitka spruce in Washington.

The ash borer, *Podosesia fraxini* Lug.—The larvae of this moth attack *Fraxinus americana*, *F. lanceolata*, and *F. excelsior*, also mountain ash, *Sorbus americana*, causing large rough, knotlike growths on the trunk and larger limbs. The caterpillars mine the limbs and trunks of small trees.

The only remedy is to cut and burn infested parts. Paints and washes of various kinds have been recommended but are hardly worth while applying. The distribution is general.

Western poplar borer, *Paranthrene robiniae* Hy. Edw., is a black and yellow species with brownish front margins on the forewings. The adults appear from March (California) to August (Washington). The larvae bore in the trunks and larger branches of willow, poplar, and locust in the Pacific Coast states, Idaho, and Nevada.

Poplar borer, *P. tricincta* Har., a species similar in habits to the ash borer, is very destructive to young poplars in the East and Middle West, especially to *Populus candicans* and *P. deltoides*.

Paranthrene asilipennis Bdv. attacks the roots and base of the trunks of oaks, ash, and alder in eastern United States. *P. simulans* Grote var. *luggeri* Hy. Edw. is found in black and red oaks and rarely in chestnuts in eastern United States.

P. palmi Hy. Edw. occurs in oaks from the Atlantic to the Pacific Coast states. *P. dolli* Neum. attacks the solid wood of poplars and willows in the eastern states.

The hornet moth, *Aegeria apiformis* Clerck, has a wing expanse of from 30 to 45 mm. The wings are transparent with brown borders. The thorax is brown with a large yellow spot on each side. Abdomen brown with a broad yellow band on the anterior portion of each seg-

ment except the last two which are yellow. The larvae make extensive burrows in the roots, trunks, and large limbs of poplars and willows. The moth occurs in nearly all parts of the United States. In many places it is so abundant and destructive that poplar trees cannot be grown satisfactorily.

The cottonwood crown borer, *Aegeria tibialis* Harris, is also widely distributed, attacking cottonwood from the east to the west coast of Canada and the United States. It is often mistaken for the preceding species. The adults have the abdominal segments black, all but the second and fourth with a narrow posterior yellow margin.

The western sycamore borer, *Synanthedon mellinipennis* Bdv., is a serious pest of sycamores in California. It also occurs in oak and ceanothus. The adults look very much like yellow jackets. Within recent years these larvae have been doing much damage to live oak in some parts of California. They work principally in the bark, and they may affect the cambium also.

The maple borer, *Synanthedon acerni* Clem.—This is a very destructive borer in both hard and soft maple in the eastern United States and is also common in the upper Mississippi Valley.

The whitish larva can be found just beneath the bark in early spring, maturing in May or June. It eats its way nearly through the bark, then pupates. When ready to transform to the adult the pupa forces itself partly out of the burrow, transformation takes place, the pupa case splits, and the adult emerges as a handsome, wasplike moth, with thin, transparent wings and slender, yellow body banded and trimmed with red.

S. corni Hy. Edw. is found in the small branches of silver and red maple in the eastern states. *S. scitula* Harris works in hickory, oak, and chestnut in the Eastern states and Canada. *S. acerrubri* Eng. is found in maple, especially red maple in eastern United States. *S. castaneae* Busck bores in chestnut in eastern United States. *S. pictipes* G. & R. although primarily a pest of orchard trees also attacks chestnut. *S. albicornis* Hy. Edw. bores in the solid wood of willow and poplar in eastern United States. *S. bolteri* Hy. Edw. lives in the solid wood of willow well above the ground. *S. sigmoidea* Hy. Edw. attacks the stems of black willow along the Atlantic coast. *S. culiciformis* Linn. is found in birch from the Rocky Mountains westward. *S. americana* Beut. bores in willows and alders from Colorado westward.

The Carpenter Moths

These belong to the family Cossidae. The adult moths are of medium or large size, have spindle-shaped bodies and narrow, strong

wings, some species resembling hawk moths, Sphingidae. The antennae of the males are mostly bipectinate; those of the females are either very slightly bipectinate or ciliate. The colors are usually dull, and the proboscis is lacking.

The larvae are wood borers, many of them living in solid wood of live trees where from two to four years is required for development.

The moths fly by night and lay their eggs on the bark of trees or within the tunnels from which adult moths have emerged. The caterpillars are nearly naked and are grublike in form, though they have prolegs as well as true legs. They pupate within a cocoon in the mine made by the larvae. When ready for the adult to emerge

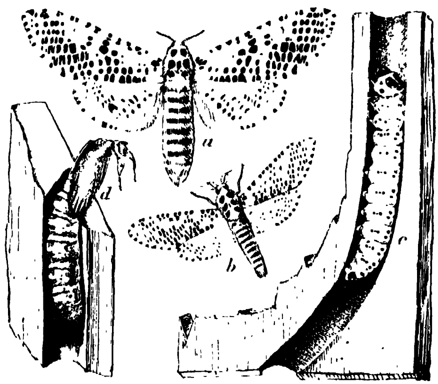

FIG. 189. The leopard moth, *Zeuzera pyrina* L. *a*, female; *b*, male; *c*, larva in burrows; *d*, moth issuing from pupa case. × .5. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Farmers' Bul.* 1169.)

the pupa works its way partially out from its burrow by means of backward-projecting, sawlike spines, one or two rows occurring on each abdominal segment.

The family Cossidae is represented in our fauna by thirty-four described species, many of them little known.

The leopard moth, *Zeuzera pyrina* L., was introduced into the United States from Europe about 1879. It attacks shade trees, principally in the cities of the East. Elms, chestnut, poplar, ash, oak, and walnut are most commonly infested, but almost any tree except conifers is liable to be attacked.

The adult female is much larger than the male and is a feeble flier, while the male is more slender with stout wings and broad, feathered antennae. Both sexes are spotted, giving the common name.

Adults appear in late May at which time the female deposits her salmon-colored oval eggs in the crevices of bark. One to four eggs are placed in each group, each female laying a large number (800 eggs

have been deposited by a single female). The eggs hatch in 8 to 10 days, and the young larvae bore into the branches, hollowing them out, so as to leave only a shell. When they later attack the larger limbs, they confine their work to the sapwood. The following year the bark splits over their mines, allowing other insects and fungi an excellent opportunity to enter and finish destroying the tree.

Several methods of control have been recommended for the species belonging to this group. Cutting out badly infested trees, from which

FIG. 190.—The carpenter worm moths, *Prionoxystus robiniae* Peck. Male, above, female, below. Natural size. (*Photo by Slingerland.*)

numerous adults emerge annually to attack other trees, is well worth while. Cutting out the larvae or injecting carbon bisulphide into the mines is also a useful measure.

The oak or hickory cossid, *Cossula magnifica* Stkr.—The adult moths emerge during May and June and lay their eggs shortly after. Upon hatching the larvae first attack the smaller twigs, in which they tunnel out the center or pith. Next they attack the larger limbs; and finally in the early fall they are to be found attacking the main trunks of the trees or large lower branches into which they bore galleries parallel with the grain.

Pecans, hickory, and oaks are subject to attack in the eastern and southern states.

The lesser oak carpenter worm, *Prionoxystus macmurtrei* Guer.—Eggs are deposited in cracks and crevices of bark at the edges of wood or even upon smooth surface of the host. From 50 to 250 eggs are to be found in a cluster. These eggs hatch in 10 days or 2 weeks, the caterpillars boring into the bark and leaving small bits of silk, borings, and excrement behind showing where the work started; at the end of the first season the larva will be 12 mm. long and will have excavated an area of several square inches in the bark where the winter is spent. During the second summer, work is extended out along several branches into the sapwood or even into the heartwood where the second winter is passed. During the third summer the borer works in the heartwood to the very center of the tree, and when the tree is heavily infested the large tunnels cross and recross, forming a labyrinth of galleries running through the wood. The third winter is passed as pupae. The adults emerge to mate and deposit eggs the fourth season after they are hatched. All parts of the tree from small branches to trunk are subject to attack. When small branches are attacked they are often killed, and these dead branches give additional evidence of attack.

FIG. 191.—Carpenter worms, *Prionoxystus robiniae* Peck, in oak. Slightly reduced. (*Photo by Slingerland.*)

The same tree may be attacked year after year and serve as a "brood tree" from which successive generations of moths spread to attack surrounding trees.

Pupation occurs in a silk-lined chamber at the end of the tunnel. Emergence starts in late May and continues to the end of June when the pupa, by means of its spines, moves to the mouth of the tunnel and projects sufficiently to allow the moth to escape.

The species works in various oaks in the eastern United States and Canada.

The carpenter worm, *Prionoxystus robiniae* Peck.—This moth is sometimes termed the goat moth because of its offensive odor. The female has a wing expanse of 50 to 85 mm. and has gray wings with irregular black lines and spots. The male is smaller and has darker forewings and yellowish hind wings. It is widely dis-

tributed from the Atlantic to the Pacific Coast, the larvae boring in oak, elm, locust, willow, box elder, ash, and other broadleaf trees. It is sometimes very destructive. The life history is similar to that of the preceding species. For valuable trees Burke suggests caging the trunks to capture the emerging adults and prevent reinfestation annually.

The poplar carpenter worm, *Acossus centerensis* Lint., occurs in poplars from Quebec to New Jersey and Illinois. *A. populi* Wlk. infest poplars and cottonwoods from the Atlantic to the Pacific Coast.

FIG. 192.—Work of carpenter worm, *Prionoxystus robiniae* Peck, in black oak.

The pine carpenter worm, *Givira lotta* B. & M.—The boring caterpillar is white and 32 mm. long when full-grown. It mines the outer portions of living bark of *Pinus ponderosa,* usually near the base. Pupation takes place in the tunnel.

Since the caterpillars do not penetrate to the cambium, the direct damage is negligible. Indirectly, the wounds offer ideal conditions for the entrance of other destructive insects and for the spores of injurious fungi.

Ponderosa pines in the central Rocky Mountain region are hosts for this insect.

The Zimmerman pine moth, *Dioryctria (Pinipestis) zimmermani* (Grote), family Pyralididae.—The moth is about 12 mm. in length

with a wing expanse of 30 to 38 mm. The sexes are very similar in size and color. The body is grayish, the forewings are shaded reddish on the basal and terminal fields, the middle spaces, marked off by W-shaped lines, are blackish and gray with white lines on brownish fields. The posterior pair of wings are pale yellowish white.

The full-grown larva is about 18 mm. long. The head is brown with black mandibles, body naked with a series of dots from each of which issues a single bristle. The color varies with the host; in the yellow pine it is a dirty white, in the Douglas fir a vivid green.

The newly formed chrysalids are light brown in color, gradually becoming darker as the moth within develops. The chrysalis is cylindrical, about 18 mm. long, slender, and without spines on the segments.

The date upon which the adults begin to emerge varies with latitude and altitudes from April to September, the greater number appearing during June and July. Mating takes place shortly after emergence, and the female deposits her eggs in groups on the bark of the host. The eggs hatch in about two weeks, and the larvae bore into the tree and give evidence of the attack by the mixture of coarse castings and brown borings which are thrown out through the entrance holes. When about half-grown the larva often leaves the place where it hatches and bores into the tree, sometimes migrating several feet. On reaching maturity it bursts the chrysalis skin, leaves the casting behind, and emerges through the thin pitch covering at the mouth of the tunnel.

This insect is found throughout the United States.

It has been reported as attacking the following species of trees: ponderosa pine, *Pinus ponderosa;* lodgepole pine, *P. contorta;* white pine, *P. strobus;* red pine, *P. resinosa;* Austrian pine, *P. austriaca;* Scotch pine, *P. sylvestris;* Swiss pine, P. *cembra;* and the Douglas fir, *Pseudotsuga taxifolia.*

The nature of its ravages is the same in all its host plants. It causes "spike tops" in mature timber and often kills outright large quantities of the younger stands or second growth.

The moth requires old spike-top or defective trees for brood trees from which to operate successfully. From these trees, which are common in the virgin forest and are often left for seed trees in stands that are under management, the moths go to the second growth and attack trees from a few inches to several feet in diameter. Healthy, vigorous trees seem to be preferred.

Infestation is usually on the middle trunk. Seldom do the moths attack a tree less than 10 ft. from the top or base. The bark on infested areas shrinks, cracks, and appears as though it has been

subjected to heat. Large pitch tubes and masses of pitch or thin layers of it spread over the surface and so permeates the wood that the lumber cut from such logs is either greatly reduced in value or useless. The inner bark becomes spongy, swells, and often bursts. The trunk takes on an unhealthy and rough appearance. Reinfestation takes place at the edges of the wounds, and so in a few years the tree is girdled, and the top dies.

Good forest management will keep this insect in check. If seed trees are left, they should be cut as soon as the area is seeded up and not be left for the second cutting of the whole area. In any areas where the moth shows its presence, cut all spike-top trees, lightning struck, and heavily branched mature trees for firewood or rough lumber. All infested trees cut should be used before spring or destroyed by burning. If these brood trees are removed, the area will remain free from the ravages of the moth, since the natural enemies will take care of the few that have escaped.

The larvae of *Laspeyresia laricana* (Busck), family Olethreutidae, mine the cambium of *Larix occidentalis* and *Pseudotsuga taxifolia* in the northern Rocky Mountain region.

The larvae of *Laspeyresia leucobasis* Busck attack the bark of *Picea engelmanni* and *Larix occidentalis*.

BUTTERFLIES

Of the six families of butterflies found in the United States two are worthy of attention from the forest entomologist. The first of these, the Pieridae, are mostly white, yellow, or orange and have six well-developed legs. The other family, the Nymphalidae, have only four well-developed legs, the forelegs being much shorter than the others.

The Pierids

Familiar examples of the family Pieridae are the so-called cabbage butterflies or "whites" and "yellows" of the roadside. The majority of the species are of medium size and white or yellow in color, sometimes with dark spots. The larvae are mostly green, with longitudinal stripes of a lighter color. The chrysalids are naked, supported at the posterior tip and also by a silken bridle. They are distinguished from the other butterfly pupae by the conspicuous median pointed process on the head end.

The pine butterfly, *Neophasia menapia* Feld.—The adult has a wing expanse of about 38 mm.; head and body black above, white below, covered with long, silky hairs. The wings are white with a black line along the costal margin of the forewings and a black pattern

along the apical margin of both wings. The markings of the male are darker than those of the female.

The full-grown caterpillar is slightly more than 25 mm. long; the body is dark green with two white stripes along each side. There are three pairs of thoracic legs and four pairs of abdominal prolegs besides the anal prolegs.

The chrysalid is 18 mm. long, dark green striped with white, and is attached to the bark of the host tree, shrubbery, or other growth near by.

Winter is passed in the egg stage, and the young pale-green caterpillars appear in June and feed on the needles of various pines. They are gregarious until about half-grown. Approximately seven weeks

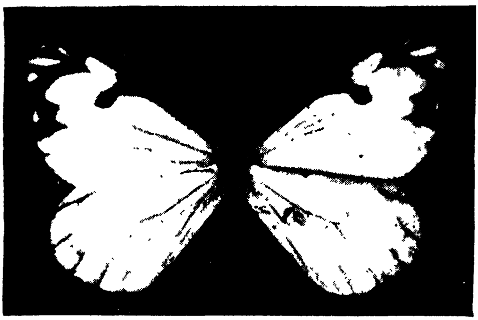

FIG. 193.—The pine butterfly, *Neophasia menapia* Feld. Slightly enlarged.

is required for the larva to become mature. At this time it lowers itself to the ground, fastens the tip of the body to any convenient object, and goes into the pupal state. Two to three weeks later the adults appear. Mating occurs very soon, and the female deposits her light-green eggs in rows of five to twenty on the needles, usually high up in the tree. These remain until the following June. There is only one generation a year.

This species, like many other defoliators, appears in countless numbers from time to time, defoliates large bodies of timber, and then disappears only to reappear after an interval to repeat the destruction. Thousands of acres of pines are stripped of their needles and either killed outright or rendered an easy prey for other enemies.

Under present forest conditions, man must depend upon the natural enemies to take care of the situation or apply dust by the use of the airplane. Fortunately, the pine butterfly has several enemies, the most important being an ichneumon fly, *Theronia fulvescens* Cress, which parasitizes the caterpillars and is credited by Aldrich with

practically exterminating the butterfly in Idaho in 1898. Evenden credits natural enemies with ending the epidemic in Idaho in 1923.

The Brush-footed Butterflies

The family Nymphalidae is the largest family of butterflies. Only a few of the 250 species are of importance to the forester.

Fig. 194.—The mourning cloak butterfly, *Euvanessa antiopa* L. Larvae, pupa and adults.

The family is characterized by peculiar forelegs which are reduced to small, brushlike processes without tarsal claws on the feet; these feet lie folded along the thorax.

The chrysalids are naked, angular, and hang head down, suspended by the anal end only.

Many of the common butterflies such as the monarch, *Danaus archippus* Fabr.; the red admiral, *Vanessa atlanta* L.; the painted beauty, *V. virginiensis* Dur.; and the cosmopolite, *V. cardui* L., belong

to this family. The larvae of some of these sometimes occur in astounding numbers and migrate for some distances in search of their favorite food.

The mourning cloak or spiny elm caterpillar, *Euvanessa* (*Aglais*) *antiopa* L., sometimes occurs in destructive numbers on elms, willows, and other trees and shrubs, often stripping the limbs of their foliage. The larvae are blackish with a row of brown spots above. The body is provided with long, stiff, forked spines. The adult is brownish black with the wings bordered with a yellow band inside which is a row of blue or purple spots.

Fig. 195.—The California tortoise shell, *Aglais californica* (Bdv.). × .5. Pupae and adults. (*Photo by Miller.*)

The California tortoise shell, *Aglais californica* (Bdv.), is especially common in northern California and southern Oregon. At times, like the Great Basin tent caterpillar, it defoliates the ceanothus over extensive areas in northeastern California, often killing it and thus producing a great fire hazard as well as destroying one of the best snow-retaining factors that we have.

Several of the Papilionidae or Swallowtail butterflies are also of economic importance on shade trees. *Papilio rutulus* Bdv., which normally feeds in willow and poplar, is often common on the oriental sycamore in the San Francisco Bay region and would be quite destructive if not held in check by parasites.

Among the Hesperidae or skippers are also several that might be mentioned here. *Epargyreus tityrus* Fab. which ranges clear across the continent is often somewhat injurious to the foliage of the honey locust, its preferred food plant.

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CHAPTER IX

SAWFLIES, HORNTAILS, BEES, AND ANTS

The order Hymenoptera is characterized by possessing four membranous wings usually with but few veins and cells. The hind wings are smaller than the forewings. The mouth parts are formed for chewing or for chewing and sucking. The ovipositor of the female is often developed into a piercing or sawing organ or into a sting.

The metamorphosis is complete. The larvae are usually grublike or maggotlike. In one group they are caterpillar-like or sluglike. The pupae may or may not be enclosed in a cocoon.

The members of this order are mostly beneficial; comparatively few are injurious. The activities of the honeybee and many other bees in pollination or cross-fertilization of flowers are important factors in the production of fruit and seeds. The parasitic forms, belonging to several different families, are responsible for the control of many important pests.

The injurious forms are to be found in the groups of leaf feeders, leaf miners, seed chalcids, and gall makers.

Numerous systems of classification for this order have been proposed by different workers. Many of the old family names have been changed, and the families have been grouped into superfamilies or divided into subfamilies. The classification adopted by Comstock in his "Introduction to Entomology" will be followed here.

The order is divided into three suborders; the Chalastogastra which includes the sawflies and horntails; the Idiogastra, a small family of rather rare, parasitic insects; and the Clistogastra which includes the rest of the families grouped into several superfamilies.

THE SAWFLIES AND HORNTAILS

To the suborder Chalastogastra belong all of the Hymenoptera that injure forest or shade trees by feeding on foliage and many that bore into the wood. The larvae of some resemble caterpillars but differ in having more than five pairs of prolegs; others are sluglike and slimy; still others, the wood borers, are cylindrical and have the abdomen tipped with a spine. The adults differ from other members of the order in that the abdomen is broadly joined to the thorax and none of the basal segments is narrowed or constricted.

The Typical Sawflies

The sawflies family, Tenthredinidae, include more than seven-eighths of the members of this suborder. The larvae of most species are caterpillar-like. They have well-developed true legs and six to eight pairs of prolegs. Some of the larvae are sluglike and are covered over with slime.

The larvae of most species, like caterpillars, feed on the foliage of plants. Several species belonging to the genus *Pontania* attack

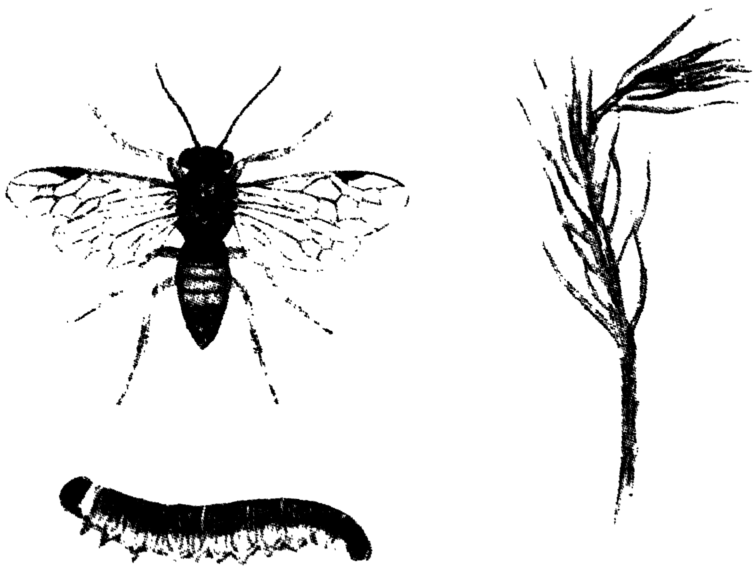

FIG. 196. Larch sawfly, *Lygaeonematus erichsonii*. Greatly enlarged. (*Can. Dept. Agric. Bull.* 10, *second series*.)

willows, causing conspicuous galls on the leaves or stems. A few are leaf miners.

The larch sawfly, *Lygaeonematus erichsonii* (Hartig), is the most important sawfly attacking conifers. From time to time it appears in destructive numbers, defoliating extensive areas of larch or tamarack in Canada and the northern part of the United States. It may also attack some other trees and shrubs.

The adult is a large, black sawfly with reddish bands on the abdomen. When ready to lay her eggs, usually in June or July, the female saws a slit in the terminal shoots of the larch and places the eggs in two alternate rows. This causes the shoots to curl. The

newly hatched larvae feed on the leaves just behind the terminal whorls. As they grow older they move from one branch to another, stripping the leaves as they go. The body is greenish, resembling the color of the underside of larch leaf; the head is round and jet-black.

Little can be done toward controlling this insect in the swamp areas. Where it is possible to reach the trees with a sprayer, arsenical sprays are effective. Importation of one of the European parasites has evidently proved successful in Manitoba (Watson, 1931).

Redheaded pine sawfly, *Neodiprion lecontei* Fitch, is a common enemy of several species of young pines. On account of the characteristic color of the head of the larvae it is often called the redheaded sawfly. The larvae feed in colonies on the pine needles, sometimes attacking the tender bark as well. When full-grown they are yellowish white in color with rows of black spots on the sides. There are two broods each year. This insect is known to occur as far south as Florida and as far west as the Mississippi River.

In nurseries and parks these sawflies may be controlled with arsenical sprays (2 lb. of arsenate of lead to 50 gal. of water), or the larvae may be knocked from the trees and crushed.

The introduced pine sawfly, *Diprion simile* (Hart.), has now become well-established in this country. It is found most commonly in nurseries and introduced ornamental species of pines. There is danger, however, of its spreading farther. In Europe these pests are controlled by hand picking or by jarring them from the trees and crushing them. When more extensive control measures are necessary the infested trees may be sprayed with arsenate of lead.

The European spruce sawfly, *D. polytomum* Hart., has recently become firmly established in parts of eastern Canada and is doing much damage to both the white and the black spruce. As the larvae feed only on the old foliage the trees are not killed but their growth may be seriously retarded.

The larvae hibernate in cocoons on the ground and are subject to the attacks of several natural enemies such as shrews and mice. Dusting with calcium arsenate from an airplane would probably be feasible in some localities.

The spruce sawfly, *Neodiprion abietis* (Harr.), attacks spruce and fir. *N. pinetum* (Nort.) is common on white and hard pines. *N. fabricii* (Leach) and *N. excitans* Roh. occur on some of the southern pines. *N. rohweri* Mid. feeds on *P. monophyla* in California and *P. edulis* in Colorado. *N. swainei* Mid. is found on *P. banksiana* in Quebec. *N. burkei* Mid. was reared from *P. contorta* in Montana where it defoliated many trees. Abbott's sawfly, *N. abbotti* Leach, feeds on white pine and pitch pine in the East.

N. banksianae Roh. has caused considerable damage to jack pine in Minnesota, Idaho, and Montana during the past few years. *N. grandis* Roh. is a serious enemy of the yellow pine in Nebraska. Some years it defoliates many small trees and the tops of large ones. *N. gillettei* MacG. feeds on yellow pine in Colorado.

Ponderosa-pine sawfly, *N. fulviceps* (Cress.), in the adult stage is a black-bodied sawfly about 6 mm. long with prominent feathery antennae. The larvae, which are green slugs with black heads, feed upon the foliage of ponderosa pine. When full-grown (about 12 mm. long) they make a cylindrical, brown, papery cocoon which is attached to the needles and in which they change to the adult form.

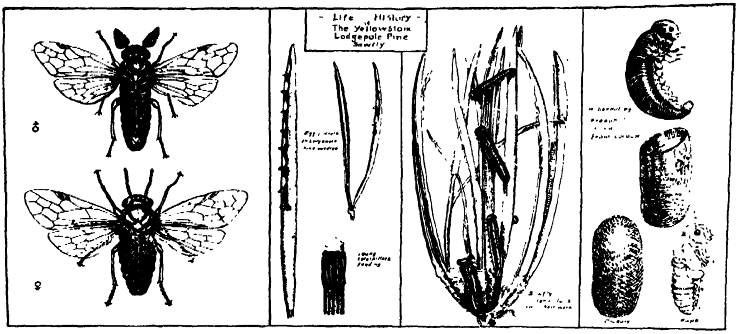

FIG. 197.—Yellowstone lodgepole pine sawfly, *Neodiprion burkei* Mid. Upper left male and female; center right, egg pockets on needles and young larvae feeding; center left, larvae feeding on needles; upper right, hibernating larva removed from cocoon; lower right, pupa removed from cocoon. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Edmonston.*)

The sugar-pine sawfly, *Neodiprion edwardsii* (Nort.), is an insect similar to the preceding except that the adults are yellow-bodied instead of black. The slugs feed upon the foliage of sugar pine and western white pine in the Sierras.

Several other undescribed species of *Neodiprion* attack the foliage of lodgepole pine, the true firs, and other conifers.

Strongylogaster pacificus MacG. in the larval stage is a bluish-green slug which constructs round, sawdust-packed cells in the outer corky bark of ponderosa pine, in which to pupate. The grubs probably feed upon the foliage of the pines.

The cedar cone sawfly, *Augomonoctenus libocedrii* Roh., feeds in the cones of incense cedar in Oregon.

There are several other species of sawflies, some of them unnamed, attacking conifers in the western states. But little is known of these.

The elm leaf miner, *Kaliofenusa ulmi* (Sund.), mines in the leaves of American and European elms in the eastern states.

The birch leaf miner, *Fenusa pumila* Klug., commonly mines in the leaves of birch in New York. *F. dohrnii* (Fischb.) mines in the leaves of European elms and alders.

FIG. 198.—Work of cedar cone sawfly, *Augomonoctenus libocedrii* Roh.

THE WEB-SPINNING AND THE LEAF-ROLLING SAWFLIES

These sawflies belong to the family Pamphilidae. The body is robust; the posterior margin of the pronotum is straight or nearly so; the mesonotum and the ovipositor are short. The larvae have long seven-segmented antennae and well-developed thoracic legs.

The larvae of the species whose habits are known either build nests by tying the leaves of their food plants together with a web or by rolling the edge of a leaf into a tube. Both coniferous and broad-leaved trees are infested.

Monterey-pine sawfly, *Itycorsia* sp., is another species that infests coniferous trees. It occurs in the native groves of Monterey pines at Del Monte, Calif., and sometimes strips numerous trees of most of their foliage. The large trees usually recover from the defoliation, but many small ones die. The species might become a serious pest if it should get into the planted forests of Monterey pine in New Zealand and other parts of the world.

The adults of the Monterey-pine sawfly appear on the foliage of the pine during the spring or early summer. They lay canoe-shaped eggs singly on the surface of the needles. The larvae feed within a nest formed by tying several needles together. In midsummer they become full-grown, drop to the ground, wriggle down 1 in. or more into the soil, curl up into a question mark, and rest until the next spring when they pupate, transform to the adult, emerge from the soil, and fly to the foliage to start another generation.

Several other species of *Itycorsia*, of whose habits little is known, infest pine in other parts of North America. One of these, *I. zappei* Roh., infests Austrian and white pine in Connecticut.

The Xyelid Sawflies

The members of the family Xyelidae can be distinguished by the form of the antennae and the venation of the wings. The basal segments of the antennae are consolidated in such a way as to make what appears to be a very long third segment. The free part of vein R2 is present.

The larvae feed on the foliage of hickory, butternut, pecan, and elm. Some have been reported as inhabiting fir trees. *Xyela minor* Nort. is found on pine where it is said to feed on the staminate flowers.

These insects are usually of little or no economic importance.

The Stem Sawflies

Most of the larvae of this group, family Cephidae, bore into the stems of grasses and other plants, but some attack trees and shrubs.

The cedar horntail, *Syntexis libocedri* Roh., attacks the outer wood of incense cedar in California and Oregon. The adults are about 8 mm. long, black with greenish markings on the sides of the thorax, and with reddish legs.

The Cimbicid Sawflies

The family Cimbicidae includes some of our largest sawflies. The body is stout. The spiracles are situated in pleural sclerites on the sides of the abdomen. The antennae are clavate.

The elm sawfly, *Cimbex americana* (Leach), is a common, widely distributed species. It varies greatly in color, and several varieties have been described. The body is steel blue or black with three or four yellowish spots on the sides. The feet and antennae are yellow. The larvae are greenish with a black stripe along the back and black spots around the spiracles. They feed on elm, linden, maple, and other deciduous trees. *C. pacifica* Cress., a brownish-red species, occurs in the Northwest. *C. rubida* Cress. is reddish marked with black and limited to California and Nevada. It sometimes defoliates considerable portions of willows.

The Horntails

The members of the family Siricidae are called horntails because the abdomen bears a hornlike projection. This is short in the male, but in the female it is much longer and often spear-shaped. The ovipositor is long and is fitted for boring. It is attached not to the

tip of the abdomen but far forward on the ventral side. The larvae live in the trunks of trees where they are often destructive. They, too, have a prominent spine at the tip of the body.

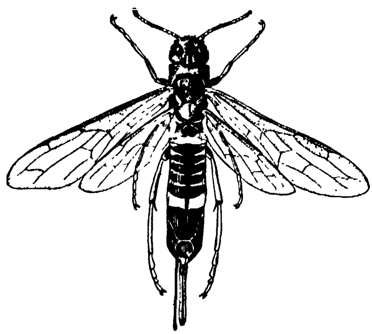

FIG. 199.—The pigeon horntail, *Tremex columba* L. × 1. (*Jordan and Kellogg's Animal Life.*)

The pigeon horntail, *Tremex columba* (L.), is the best known representative of this group. The adults are 25 mm. or more long, blackish, with the head and thorax often reddish and black, appendages marked with yellow.

"The adults of this species vary in color and marking; based on these variations, three fairly distinct races have been recognized, which to a considerable extent are geographical, although their ranges overlap. In the typical form, race *columba*, the abdomen is black, with ocher-yellow bands and spots along the sides: this is the common form in Quebec, Ontario, and the northeastern United States. In the race *aureus* the ground color of the abdomen is yellow, and the markings black; this is the common form in the Rocky Mountains and is found on the north Pacific Coast. In the race *sericeus* the entire body is fulvous, the legs beyond the femora yellow, and the wings dark reddish brown; this race is found in the southeastern United States and as far north as Pennsylvania and west to Utah" (Comstock, 1924).

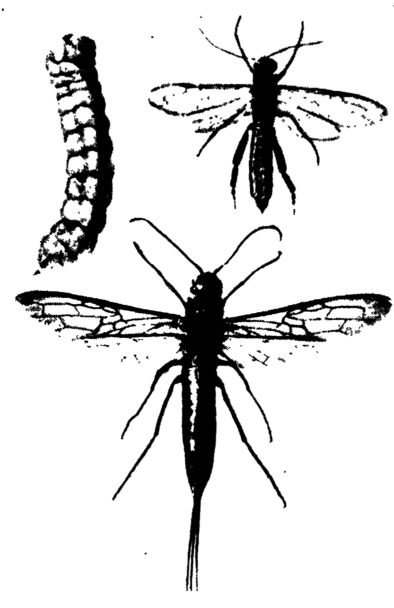

FIG. 200.—The western horntail, *Sirex areolatus* (Cress.). × 1. Larva, male (above) and female. (*Photo by Matthews.*)

The females lay their eggs in maple, elm, oak, and beech. The ovipositor is often thrust into the bark for a distance of half an inch or more. Not infrequently the insect is unable to remove the ovipositor from the bark, and the living or dead bodies are sometimes found fastened on the trunks of trees.

The larvae are long, white, and cylindrical, often reaching a length of more than 50 mm. and a diameter of 6 mm. They make

irregular channels in the wood of the infested trees and thus do considerable damage.

This and other wood-boring horntails are usually held in check by ichneumon flies. *Thalessa lunator* (Fab.) may often be seen drilling in the bark of *Tremex*-infested trees.

The western horntail, *Sirex areolatus* (Cress.), is a common western representative of this family. The female is dark, metallic blue with smoky wings. The larvae are yellowish white and 25 to 35 mm. long. They are found boring in the sapwood and heartwood of pine, cypress,

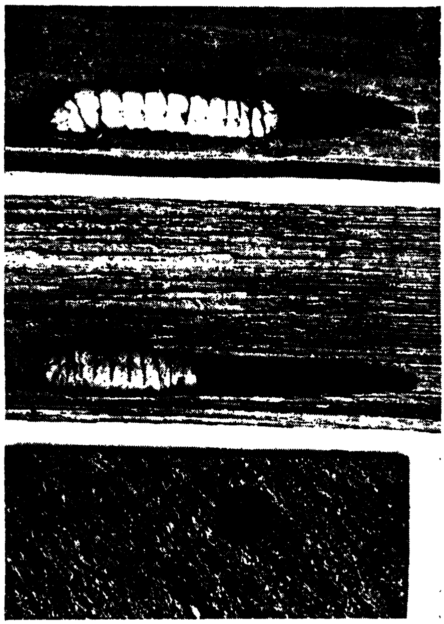

FIG. 201.—Larvae and work of the western horntail, *Sirex areolatus* (Cress.). × 1. (*Photo by Matthews.*)

cedar, redwood, Douglas fir, and some other trees. It occurs throughout the Rocky Mountain and Pacific Coast states, extending into British Columbia.

The polished horntail, *S. juvencus* (L.), is dark metallic blue with wings hyaline or slightly clouded on the outer margins. It is widely distributed over the New England, Rocky Mountain and Pacific Coast states, and in Canada. The larvae are found in many different species of conifers.

The California horntail, *S. californicus* (Ashm.), is a large species with dark, metallic-blue body, buff-colored wings, and black legs. It is known to attack ponderosa pine, Jeffrey pine, and Douglas fir.

The males are about 12 to 18 mm. long, and the females from 25 to 50 mm. long including the ovipositor.

Behrens' horntail, *S. behrensi* (Cress.), is a small insect about 15 mm. in length with the head and thorax blue-black and the apical segments of the abdomen reddish brown. The ovipositor is very short. This species is commonly found attacking ponderosa pine and sugar pine, also cypress and acacias in the San Francisco Bay region.

The white-horned urocerus, *Urocerus albicornis* (Fab.), is found throughout Canada and northern United States and along the Pacific Coast and into Arizona and New Mexico. It is black with the middle of the antennae, cheeks, bases of tibiae, and tarsi white. White spots are also sometimes found on the sides of the abdomen; the wings are smoky. The species attacks many kinds of conifers.

The yellow-horned urocerus, *U. flavicornis* Fab., is black with the antennae, tibia, tarsi, and second, seventh, and eighth abdominal segments yellow or reddish. The wings are subhyaline or yellowish toward the base. The female is 22 to 33 mm. long. The male is smaller with the third to sixth abdominal segments yellow. This species is widely distributed, being found in most regions where pine, fir, and other coniferous trees grow.

The California urocerus, *U. californicus* (Nort.), has a dull and shining black body with golden-yellow wings. The antennae, cheeks, bases of tibia and tarsi, and a spot on the abdomen are yellow. The female is 28 to 35 mm. long. The male is smaller and has a reddish or brownish thorax; the antennae, legs, and abdomen are yellowish red. The larvae are found in pines and firs throughout the West Coast region.

Morrison's horntail, *Xeris morrisoni* (Cress.), is found throughout the Rocky Mountain and West Coast states and in British Columbia. It attacks various coniferous trees. *X. spectrum* (L.) has much the same distribution. *X.* sp. is common in cypress in central California.

The members of the suborder Idiogastra, family Oryssidae, strongly resemble the horntails, but they may be readily distinguished by the position of the antennae, which are inserted far below the eyes just above the mandibles, and by the venation of the wings and the character of the ovipositor.

The larvae of this group, as far as known, are parasitic on wood borers.

The western oryssus, *Oryssus occidentalis* (Cress.), has been shown by Burke to be parasitic on the larvae of several buprestids. *O. hopkinsi* Roh., has been found in mines of a cerambycid.

The members of the suborder Clistogastra are characterized by the base of the abdomen's being greatly constricted, forming a slender

petiole between the thorax and the larger part of the abdomen. Comstock lists forty families belonging to this suborder. Only a few of these are of especial interest to the forest entomologist.

PARASITIC HYMENOPTERA

The Braconids

The members of the family Braconidae are small or of moderate size, often highly colored. The larvae are parasitic in the larvae and pupae of Coleoptera, Lepidoptera, and other insects. Some attack adult insects, and a few live on the bodies of their hosts. Several hundred species, many of them widely distributed, are recorded from North America.

The members of the genus *Microbracon* are parasitic on lepidopterous and coleopterous larvae. *M. pini* Mues. is common on the larvae of white pine weevils. *M. xanthonotus* (Ashm.) is a common parasite of tent caterpillars.

Coeloides brunneri Vier. is an important parasite of *Dendroctonus pseudotsugae* Hopk., in the Pacific Northwest. *C. pissodis* (Ashm.) is a parasite on the white pine weevil, and *C. scolytivorus* (Cress.) has been reared from the hickory bark beetle, *Scolytus quadrispinosus* Say.

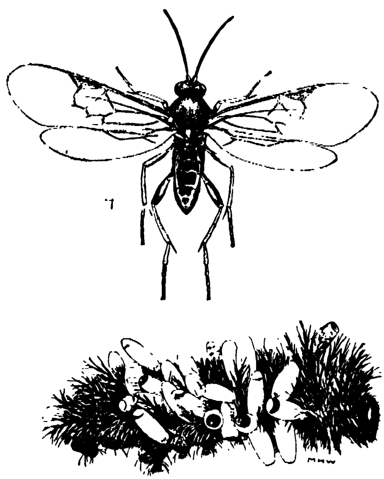

Fig. 202.—*Apanteles* sp., × 10, and cocoons, × 2, on a caterpillar which was killed by the larvae of the parasite. (*Jordan and Kellogg's Animal Life.*)

The genus *Spathius* includes a group of species which are parasitic on various wood-boring coleopterous larvae. *S. brachyurus* Ashm. is recorded as a parasite of the white-pine weevil, *Pissodes strobi* Peck.; *S. canadensis* Ashm. is a parasite of *Phloeosinus dentatus* (Say) and *Ips grandicollis* (Eich.); *S. claripennis* Ashm. is recorded as a parasite of *Polygraphus rufipennis* (Kby.); *S. pallidus* Ashm. is recorded as parasite of *I. grandicollis* (Eich.); *S. simillimus* Ashm. is recorded from New York as a parasite of *Agrilus bilineatus* (Weber); *S. tomici* Ashm. is a parasite of *Orthotomicus punctipennis* (Lec.), *Scolytus piceae* Sw., and *Polygraphus rufipennis* (Kby.); *Spathius trifasciatus* Rly. is a parasite of the hickory bark borer, *Scolytus quadrispinosus* Say, and probably attacks various other species of

Scolytus. *Spathius unifasciatus* Ashm. is a parasite of the hickory bark borer, *Scolytus quadrispinosus* Say.

Doryctes cingulata (Prov.) attacks the larvae of *Chrysobothris mali* Horn and *Agrilus angelicus* Horn. as well as numerous other borers. *Phanerotoma erythrocephala* Roh. is parasitic on *Carpocapsa toreuta* (Grote) in the cones of yellow pine in Colorado, and *P. laspyresia* Roh. occurs on the same host in California. *Aleiodes intermedius* Cress. is common on tent caterpillars. *A. parasiticus* Nort. is recorded as a parasite of *Neodiprion abietis* (Harr.).

The genus *Apanteles* includes a group of species parasitic on lepidopterous larvae. Frequently the dried, empty skin of a cater-

FIG. 203.—Aphids killed by the braconid *Aphidius* sp. × 2.

pillar covered over with minute cocoons may be found. The parasites lived in the body of the host until they were fully grown; they then made their way through the body wall of the caterpillar and spun the cocoons from which the adult braconids soon issued.

Apanteles congregatus (Say) attacks several species of sphinx moth. *A. fumiferana* Vier. is an important parasite of the spruce budworm.

The genus *Ichneutes* contains a few species that are parasitic on sawfly larvae. The genera *Helcon* and *Helconidea* include species parasitic on cerambycid larvae. *Cosmophorus hopkinsi* Ashm. is parasitic on some of the smaller Scolytidae.

The genera *Aphidius, Diaeretus, Lysiphlebus,* and others contain species that are important parasites of aphids. As the larvae develop within the body of the host they cause the abdomen of the aphid to become swollen to more than twice its normal size. The adult escapes by making a neat circular opening on the dorsal side of the

host. Frequently large colonies of aphids are quickly destroyed by these parasites.

The Ichneumon Flies

The family Ichneumonidae contains many of our best known parasites. Some of the species are small, but most of them are of moderate size or very large. They are important parasites of lepidopterous, coleopterous, and other larvae. Some of them are secondary parasites, attacking important primary parasites.

Megarhyssa lunator (Fab.) is one of the largest of these. It is mostly dark brown in color and is parasitic on the larva of the pigeon horntail. The extremely long ovipositor enables this ichneumon fly to drill a hole through the bark and into the heartwood in which a horntail larva may be working. She then lays her egg on or near the larva which is to serve as food for the parasite that hatches from the egg. *M. nortoni* (Cress.) occurs throughout Boreal North America. It is the dominant species in the mountains of the Pacific Coast. It, too, is a very large species, measuring from 25 to 38 mm. in length. The body is pale brown with yellow spots on the sides of the abdomen, at least in the female. The ovipositor is about twice as long as the body. The larvae are parasitic on the larvae of Siricidae in living or dead conifers. *M. atrata* (Fab.) is a common eastern species.

Fig. 204.—An ichneumon fly *Megarhyssa nortoni* (Cress.). × .75.

The species of the genus *Labena* are parasitic on buprestid and cerambycid larvae.

The genus *Rhyssa* includes a few widely distributed species which are parasitic on Siricidae. *R. alaskensis* Ashm. occurs in the high mountains throughout western North America. It is wholly black with clear wings. *R. lineolata* (Kby.) and *R. persuasoria* (L.) are common eastern species.

To the genus *Ophion* belong many of our common yellow-bodied ichneumon flies which are parasitic on many lepidopterous larvae, especially those of the Geometridae. The Ophionini are mostly nocturnal, especially abundant on the Pacific Coast, and apparently very beneficial. *O. bilineatus* Say is found throughout Boreal North America. It is 10 to 20 mm. long and varies in color from pale yellowish to reddish brown. Many members of the genera *Xorides*, *Deu-*

teroxorides, *Ichneumon*, and others are parasitic on wood-boring coleopterous larvae.

The Proctotrupids

Most of the members of the superfamily Proctotrupoidea are very small, black or brownish, parasitic insects. Some attack the larvae of Diptera, Coleoptera, or other orders of insects. Some are egg parasites. The eggs of practically all orders of insects are subject to the attacks of these parasites, and doubtless many injurious species are thus held in check, in a measure at least.

THE CHALCID FLIES

Numerically the Chalcidoidea is the largest superfamily of the Hymenoptera. Many thousand species are included in the group. Some of the species are of moderate size, but most of them are small, some very minute, measuring less than ¼ mm. in length.

This group is of great economic importance because nearly all of its members are parasitic on insects. Eggs, larvae, pupae, and, in a few cases, even adults are subject to the attacks of these little parasites. Many destructive leaf-feeding and wood-boring insects are attacked by various species of chalcid flies. One subfamily, the Aphelininae, includes species that attack aphids, scale insects, and aleyrodids. They are the most important factors in the natural control of many of these pests.

Not all the members of this superfamily are parasitic. The subfamily Eurytominae include some species that are phytophagus; that is, they feed on plant tissue. Wheat jointworms and strawworms belong to this group.

Seed-infesting Chalcids

The genus *Megastigmus* is of considerable importance to the forester, as it includes a number of species the larvae of which destroy the seeds of conifers. The seeds of deciduous trees and shrubs are also attacked by insects of this group.

The adults are tiny, wasplike insects marked by combinations of black and yellow colors. The egg is deposited within the immature seed by driving the long ovipositor through the protecting scales and bracts of the young cone. Oviposition occurs in the early spring or summer while the cones of the host tree are still in a tender growing condition. The puncture made by the ovipositor does not affect further growth of the cone which matures to its normal size. The larva feeds entirely on the inner tissues of the seed the outer shell

of which is not injured and continues to grow until it reaches normal size. Infested seeds resemble those that are sound and can be detected only by cutting so as to expose the inner seed cavity. The larva matures before fall and overwinters within the seed cavity. The pupa forms early the following spring, and the adult emerges soon afterward by cutting a small, round hole through the outer seed coat. The flight period corresponds to that of the early growth stages of the cones of the host tree.

Usually the greater part of the brood emerges within a year after oviposition, but from 10 to 50 per cent of the larvae may remain in the seed cavities throughout the second year. This habit appears to be an adaptation to conform to the intermittent seed-producing habits of coniferous trees.

Control appears to be impracticable in the growing seed crops. Fumigation of stored seed will not prevent the damage that has already developed during the growing period, but it has been recommended as a measure to prevent carrying the infestation into new localities where seed is to be planted.

Douglas fir seed chalcid, *Megastigmus spermotrophus* Wachtl.— This species attacks most commonly Douglas fir, *Pseudotsuga taxifolia;* it also occurs in the true firs, *Abies concolor, A. grandis, A. magnifica* and *A. shastensis.* It has been recorded throughout the Pacific Coast and southern Rocky Mountain regions. It was first found and described in 1893 from Douglas fir seed shipped from western United States to Europe.

Heavy damage was recorded at Ashland, Ore., in 1913 when nearly 50 per cent of the Douglas fir seed crop of that year was found to be infested. Usually, the infestation is much lighter, from 2 to 10 per cent of the annual seed crop being destroyed.

The adult female is brownish yellow with the face and hind margin of pronotum yellow; the ovipositor is as long as the body, dusky in color, and usually strongly curved. Wings clear with dark-brown veins; the male is much lighter in color. The length of the female is about 3 mm.; of the male, about 2.5 mm. The full-grown larva is yellowish white with brownish mouth parts; its length 2.5 to 3.5 mm.

Adults emerge in the field in April, May, and June, depending upon regional conditions, from infested seeds adhering in the cones or scattered in the forest litter. In southern Oregon oviposition was observed to occur late in April, throughout May, and during the first part of June. The females attack cones of Douglas fir from two to three weeks after the buds open. Eggs are deposited in or near the soft, milky seed which is just forming. Larvae develop within the seed during June, July, and August, each larva feeding in one seed

only during its entire development. The inner portion of the seed is entirely eaten, but the outer coat remains intact externally resembling that of the normal seed. Larvae are mature by September and pass the overwintering period within the seed where they developed. Pupae form within the seed during February, March, and April. About 10 per cent of the brood pass through the second year as mature larvae.

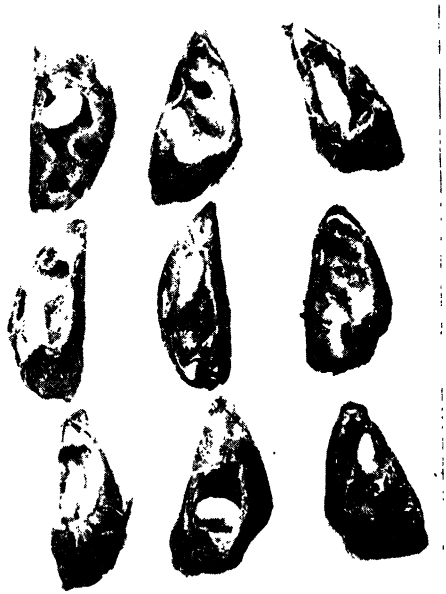

FIG. 205.—The fir seed chalcid, *Megastigmus pinus* Parf., in seeds of *Abies concolor*. × 2. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Photo by Miller.*)

Fir seed chalcid, *Megastigmus pinus* Parf. Length 4 to 5 mm.; black with orange markings; pronotum with a large, reddish-orange area. Abundant in seeds of *Abies concolor* in Oregon and California where 40 per cent of seed crop has been found to be infested during certain seasons; also found in *A. grandis, A. magnifica, A. shastensis, A. nobilis, A. amabilis* and *A. venusta.*

Spruce seed chalcid, *M. piceae* Roh.—Length 2.5 mm.; black with yellow markings. Recorded from *Picea engelmanni, P. sitchensis,* and *P. parryana.* Damage reported from Beulah, Colo., in 1913 where about 8 per cent of seed crop was destroyed.

The ponderosa pine seed chalcid, *M. albifrons* Walk.—Length 5 to 6 mm.; black and yellow forewings with brown spot. Recorded in

the seeds of *Pinus ponderosa* in the southern Sierra region at Placerville and Northfork, Calif.

Hemlock seed chalcid, *M. tsugae* Crosby.—Length 2.5 mm.; black marked with yellow; prothorax with two yellow spots. Reared from seeds of *Tsuga martensiana hookeriana* from western United States.

FIG. 206.—Work of the ponderosa pine seed chalcid, *Megastigmus albifrons* Walk., in a ponderosa pine cone. A larva and a pupa have been removed from seeds and placed on the axis of the cone. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Photo by Miller.*)

Mountain ash seed chalcid, *M. brevicaudis* Ratz.—Length 2.4 mm.; black with yellow prothorax. Reared abundantly from seeds of *Sorbus* in New York State.

Alpine fir seed chalcid, *M. lasiocarpae* Crosby.—Length 3.7 mm.; thorax and abdomen black with yellow markings on sides. Reared from seeds of *A. lasiocarpa* from Colorado.

Larch seed chalcid, *M. laricis* Marc.—Length 2.1 mm.; general color black; yellowish markings on face, base of antennae, and coxae; abdomen shining black sometimes with three indistinct yellowish markings on the sides. Living in seeds of larch, *Larix laricina*, in New York.

THE CYNIPIDS OR GALL WASPS

Some of the members of this superfamily Cynipoidea are parasitic' infesting dipterous larvae and aphids. The most common forms' however, are gall makers, producing the conspicuous galls so often found on oak trees and other trees and plants.

Galls made by mites and aphids have openings through which the gall makers can pass. Those made by the insects belonging to this group live in galls that are closed. The gall wasps must make a hole through the wall of the galls before they can escape.

The California gall wasp, *Andricus californicus* (Bass.), makes the largest and most conspicuous of these galls. It is found on deciduous oaks all along the Pacific Coast. The adults are brownish and from 3 to 5 mm. long. Eggs are laid in the oak twigs and as soon as the larvae begin to feed the globose or reniform galls begin to

appear. These are greenish at first but later become tan or whitish. They may attain a diameter of 50 to 100 mm. There may be from one to several insects in a gall.

Young trees may be deformed by the presence of numbers of these galls, and thus some injury may be done. When they become too abundant on small or particularly valuable trees they may be gathered or knocked off. Control measures are rarely necessary.

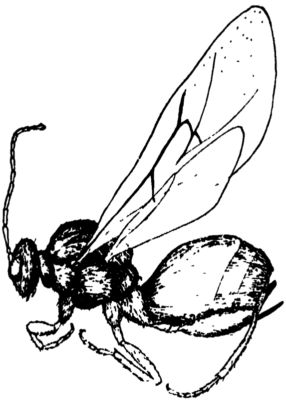

Fig. 207. The California gall fly, *Andricus californicus* Bass. × 9. (*Rose Paterson.*)

The large oak apple, *Amphibolips confluentus* (Harr.), is common on many of the eastern oaks. It is attached to the leaves and attains a diameter of from 18 to 50 mm.

The two-horned galls, *Andricus bicornis* (McCracken & Egbert), are found along the veins on the underside of the California live oak leaves. The portion of the leaf beyond the galls soon dies, and badly infested trees may have much of their foliage injured in this way.

Cynips mirabilis Kins. is the common Oregon species.

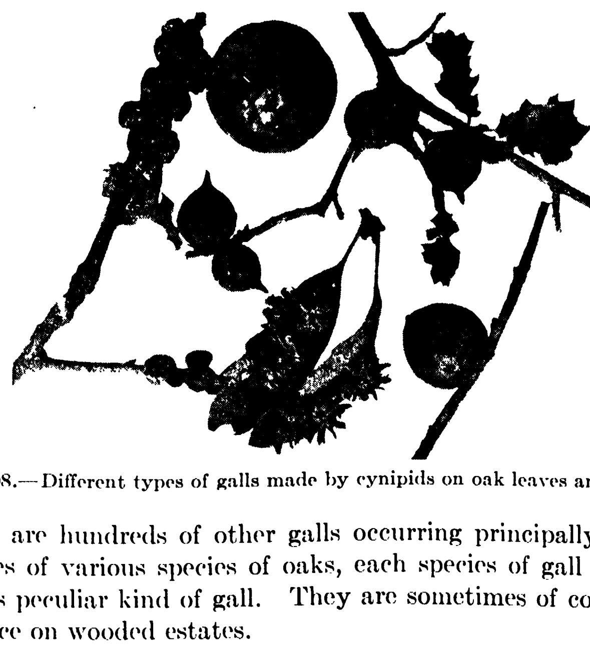

Fig. 208.—Different types of galls made by cynipids on oak leaves and twigs.

There are hundreds of other galls occurring principally on twigs and leaves of various species of oaks, each species of gall wasp producing its peculiar kind of gall. They are sometimes of considerable importance on wooded estates.

THE ANTS

Ants, family Formicidae, are among the most common and widely distributed insects. They occur in incredible numbers under almost all conditions. Many species live in dead or decaying wood, under the bark or mining deep into the wood.

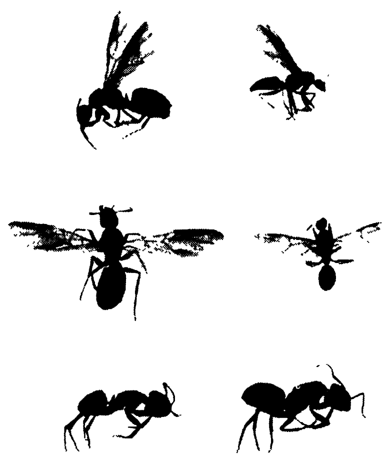

FIG. 209.—The large black carpenter ant, *Camponotus herculeanus* (L.). Winged females, left; winged males, right; wingless workers below. About natural size.

FIG. 210.—Work of carpenter ants, *Camponotus* sp., in cedar.

The carpenter ants, genus *Camponotus,* include some of our largest ants. These often construct their tunnels in stumps, fallen logs, or even standing trees. Structural timbers in buildings and bridges, telephone and telegraph poles, railroad ties, and other wood in contact with the ground are all subject to their attacks. The damage usually is slight, but it may be of much importance.

The large black carpenter ant, *Camponotus herculeanus* (L.), is cosmopolitan in its distribution. It has long been known to attack decaying or even sound timber. Graham (1918) reports that the subspecies *pennsylvanicus* DeG. attacks living white cedar in Minnesota, often causing considerable loss.

Some ants are beneficial acting as predators on harmful insects. *Formica haemorrhoidalis* Emery is one of the important predators of the western pine beetle.

BURROWING BEES AND CARPENTER BEES

Many of the carpenter bees look much like bumblebees, but they can be distinguished by the fact that the females have a dense brush of hairs on the hind legs instead of the pollen basket found on the bumblebees. The carpenter bees are usually shiny black and without the striking yellowish or reddish markings commonly seen on bumblebees. They make their nests in fence posts, telephone or telegraph poles, or bridge or other exposed structural timbers. They may

FIG. 211. Mountain carpenter bees, *Xylocopa orpifex* Smith, × .8, and examples of their work.

attack almost any kind of sound or slightly decayed wood. The burrows usually go straight into the wood for a short distance, then turn upward for a distance of 6 to 12 in. or more. As these bees often occur in colonies, they may be very destructive to building timbers. In many parts of the country they are very annoying indeed.

The carpenter bee, *Xylocopa virginica* Drury is one of the most widely distributed species throughout the East. It builds its nest in solid wood.

The mountain carpenter bee, *X. orpifex* Smith, is a large black bee 12 to 17 mm. long. It is common in the foothills and mountains along the Pacific Coast. *X. californica* Cress. and other species are also widely distributed in the Pacific Coast and Rocky Mountain states.

LEAF-CUTTER BEES

The members of the family Megachilidae build their nests in solid or decaying wood or in stems of plants. In building these nests they use bits of leaves which they cut from the leaves of various plants. Although this work may be conspicuous, it is seldom of any economic importance.

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CHAPTER X

APHIDS, SCALE INSECTS, AND OTHERS

Aphids and scale insects belong to the order Homoptera. This order also includes many other insects which vary greatly in appearance and habits; so it is difficult to give a set of characteristics that will include all of the forms. The winged forms have four membranous wings which are of the same texture throughout and are usually held rooflike over the body when at rest. The mouth parts are formed for piercing and sucking. The beak arises from the hind part of the lower side of the head, and the head, in some of the families, is bent under so far that the beak seems to arise from between the first pair of legs.

Most of the members of this order are plant feeders. Many species secrete an abundance of a sweet, sticky substance known as honeydew. This falls on the leaves or other parts of the host plant, causing a disagreeable condition, especially when a black, sooty fungus grows in the honeydew, often covering the fruit and leaves with a black soot or mold. Most families contain some species of more or less importance as enemies of shade and forest trees.

THE PLANT LICE OR APHIDS

The plant lice or aphids were formerly all included in the family Aphididae, but systematists now recognize two or more families in this group and in order to show their close relationship include them all in the superfamily Aphidoidea.

The marvelous life histories and habits of the aphids make the group one of the most interesting of all insects. They are all plant feeders, sucking the juices from the leaves, stems, or roots of their host plants, and some of them are of very great economic importance. Many species attack shade and forest trees. Some cause more or less conspicuous galls or swellings on the leaves, stems, or roots. In most species winged and wingless generations appear; often both forms may be found on their host at the same time. Some of them are restricted to one host or to closely related hosts. Others pass one part of their lives on one host and another part on another host not at all related to the first.

The wings are very delicate, membranous, and furnished with a few simple veins. The types of venation are characters much used

in classification. The beak is four segmented and may be short or as long as or longer than the body. The number of antennal segments varies from three to six. The comparative length of the segments and the presence and distribution of certain sense organs, known as sensoria, aid in identifying the species.

The secretions from the body of aphids play an important part in their lives. Some species secrete a waxy or woolly substance which may cover the insect, and this affords considerable protection. Nearly all species excrete a sweet, sticky substance which may collect in drops on the leaves of the plant. This is known as honeydew, and it was formerly supposed to come from the two tubes or cornicles that are found on the dorsal part of the sixth segment of the abdomen of many species. It is now known that the honeydew issues in drops from the alimentary canal. Flies, ants, wasps, and many other insects are very fond of this honeydew, and they will often be seen swarming around a tree or bush that is infested with aphids. Some species of aphids are carefully protected and cared for by certain kinds of ants.

The black, sooty fungus which grows in the honeydew that is secreted by aphids, scale insects, and some other Homoptera usually makes a tree look dirty and disgusting, and it also interferes with the proper functioning of the leaves. Honeydew dripping to the ground or sidewalks from aphid-infested shade or park trees makes conditions most unpleasant for pedestrians and others.

The Typical Aphids

To this family, Aphididae, belong the typical aphids. Different species vary in the details of their life history, but the following account will indicate, in a general way, what may be expected for some of our common forms.

In the spring there hatches from the overwintering eggs which have been laid on the primary host plant in the fall a generation of wingless, parthenogenetic, viviparous females known as the stem mothers. These feed on the primary host plant and in a few days begin to produce another generation of wingless, parthenogenetic, viviparous females which are known as the wingless agamic forms. These, too, soon produce another generation of their kind; and then in rapid succession a series of generations may follow. This, of course, provides for a great increase in numbers in a remarkably short time.

After a few generations—only one or two in some species; several, in others—there appears a winged, agamic form which migrates to the secondary host. Here other generations of wingless, agamic forms

are produced. Then follows another generation of winged, agamic forms which migrate back to the primary host. This generation gives birth to the sexual forms, males and females. After copulating, the females lay the eggs which are to pass the winter on the host plant. The sexual forms differ widely in appearance and habits in different species and groups. It must be remembered that there are many exceptions and variations to the foregoing generalized life history.

Almost every tree, and we might say almost every plant, is subject to the attack of one or more species of aphids. Usually little or no damage is done, but at any time conditions may be particularly favorable to the development of these little pests, and a species that is usually of no importance may become of considerable interest on account of its great numbers. We can list here only a few of the most common species that may be found on our forest or shade trees. For convenience we shall group them largely according to their habits and shall mention first those that attack the leaves of conifers and deciduous trees, then follow with the species that attack the twigs and stems.

Aphids Attacking Coniferous Needles

The spruce aphid, *Aphis abietina* Walk., is probably the most destructive aphid found attacking coniferous trees. This small, dark-green insect is a holarctic species widely distributed through southern Europe, Asia, and North America where it ranges along the Pacific Coast from British Columbia to California. It feeds on the needles of nearly all species of spruce, causing them to turn brown and fall to the ground. It is particularly destructive to Sitka spruce of the tideland belt along the Pacific Coast and in some years causes such complete defoliation that thousands of trees are killed by it. In 1918 it is reported to have destroyed 15 per cent of the spruce along the tidelands of the Pacific Northwest. Again in 1930 it caused serious damage in this same region. In other years it causes a partial defoliation which seriously weakens the trees and makes them very unsightly. The aphids pass the winter on the spruce needles as apterous females. These give rise to several generations during the spring and summer months when most of the injury is sustained. During the summer months they leave the spruce for a secondary or alternate host which is unknown at present, and then late in the fall winged migrants return to the spruce.

No practical remedy for the control of this pest on forest trees has yet been devised. On shade and ornamental spruce, it can be controlled by spraying in the early spring with such contact insecticides as oil emulsions or nicotine sulphate solution.

The Monterey pine aphid, *Essigella californica* (Essig), is often found very abundant on the leaves of Monterey pines in California, on ponderosa pine and Douglas fir in Oregon, and has been reported from other pines as far east as Maine.

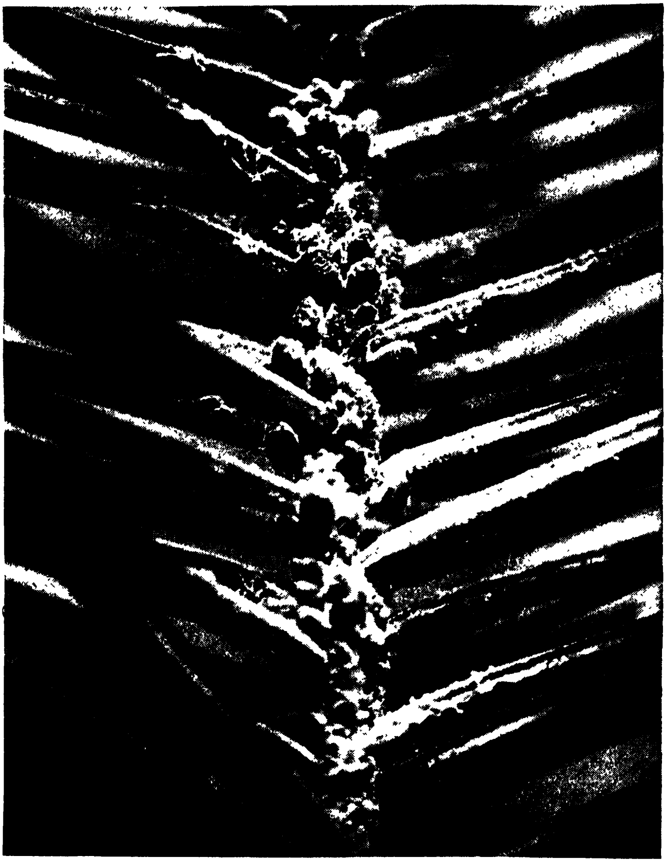

FIG. 212.—*Cinara occidentalis* (Dav.), on *Abies grandis*. × 3.

Aphids Attacking Limbs and Twigs of Conifers

The genus Cinara now includes many species formerly grouped in the genus *Lachnus*. Systematists are not agreed on the generic concepts of this group, but here we follow closely Gillette and Palmer (1931).

The life histories of the members of this group are very similar. They occur on pine, spruce, and other Pinaceae, spending their entire life on their preferred host, not migrating to others as do many species belonging to other groups. The winter is passed in the egg stage.

The first few generations in the spring are apterous, viviparous females. Later winged females occur, and finally winged or wingless males and oviparous females.

They feed chiefly on the bark, occurring in dense colonies on the smaller limbs and twigs. They produce great quantities of honeydew, and the infested trees are often covered with the sooty mould which grows in this secretion.

Only a few of the many species can be mentioned here.

The red-cedar aphis, *Cinara sabinae* (Gill.), often occurs in clusters on the twigs and smaller branches of red cedar in the East, frequently killing the infested portions of the trees, sometimes causing the death of the entire tree. The aphids usually leave the trees during the summer before the effect of their presence is noticeable on the trees, and thus they often escape notice. They are only about 3 mm. in length, and their dull-reddish color makes it difficult to detect them on the red bark of the host plant.

This species is also recorded as occurring in large colonies on *Juniperus scopulorum* in Colorado.

The white pine aphid, *C. strobi* (Fitch), is a widely distributed species in Eastern and Middlewestern states, probably occurring throughout the range of its host plant, *Pinus strobi.* The general color is blackish with white, pruinose markings. It is sometimes very injurious to young pines.

The sylvestris aphid, *C. pini* (L.), is found in most localities where its European host *Pinus sylvestris* is planted. The body is reddish brown with numerous dark specks and a pair of large spots behind the cornicles. The legs are yellowish red to dusky.

The ponderosa pine aphid, *C. ponderosae* (Will.), is metallic golden brown with more or less distinct darker longitudinal rows; cornicles and legs black. This species is found on *Pinus ponderosa* in the Rocky Mountains and West Coast regions.

The lodgepole-pine aphid, *C. oregonensis* (Will.), is brick-red in color with legs and antennae yellowish brown. It occurs on *Pinus contorta* and *P. ponderosa.*

The arborvitae aphid, *C. tujafilinus* (Del.G.), is brownish with a pruinose pattern. It infests the limbs of arborvitae, cypress, and some other conifers.

C. abietis (Fitch) is often very abundant on the terminal branches of spruce trees in midsummer. The wingless females are blackish, pubescent, with a faint, ashy stripe along the back. *C. australis* (Ash.) is a southern species occurring on the young branches of southern pine in Florida. *C. occidentalis* (Dav.) is a dark-green or brownish aphid often abundant on lowland fir on the West Coast.

C. curvipes (Patch) occurs on *Abies balsamea* in the East and has been found in Oregon and California feeding on the roots of white fir reproduction.

The cypress aphid, *Siphonatrophia cupressi* (Swain), is a large green aphid which infests certain cypress in southern California.

Mindarus abietinus Koch attacks the twigs of spruce and other conifers, often distorting and sometimes killing them.

Aphids Attacking Broadleaf Trees

The aphids attacking broadleaf trees are so numerous that only a few of the better known species can be mentioned here.

The Norway maple aphid, *Periphyllus* (*Chaitophorus*) *lyropictus* (Kess.) is a yellowish-green, brown-marked aphid which is frequently very abundant on the underside of Norway maple leaves throughout the greater part of the summer. The antennae are long and hairy and are marked with brown near the tips. The cornicles are short with black tips. The older insects are usually darker, the brown markings sometimes covering most of the upper sides of the insect. Winged females sometimes appear, but they are usually not common. This species excretes an abundance of honeydew so that walks and other places under infested trees often become sticky. A great deal of the honeydew clings to the surface of the leaves, and the black fungus develops in it. Frequently many of the leaves will drop from the trees on account of the injury inflicted by this aphid.

The painted maple aphid, *Drepanaphis acerifoliae*, (Thos.), is a prettily marked little aphid which is often found on the surface of the leaves of many species of maple. The body of the winged forms is marked with gray and black, while the apterous forms are pale yellowish. The wings are attractively marked with brownish lines along the veins. While this species is usually not so abundant as the preceding one, it sometimes occurs in numbers great enough to do considerable injury.

The common birch aphid, *Calaphis betulaecolens* (Fitch), is a large, greenish or yellowish species with very short cornicles. It is found on the underside of the birch leaves, particularly the cut-leaved variety. It produces great quantities of honeydew. The eggs are laid in cracks or crevices in the bark. It has a wide distribution.

The European birch aphid, *Euceraphis betulae* (Koch), is a large green and black aphid which may be readily distinguished from the common birch aphid by the flocculent, waxy secretion which covers the body of the insect. It is widely distributed and infests all kinds of birch trees.

The chestnut aphid, *Calaphis castaneae* (Fitch), is a small, pale-yellow species found on the underside of leaves of chestnut and hickory trees.

The elm leaf aphid, *Myzocallis ulmifolii* (Mon.), is a pale-yellow or pinkish aphid which is frequently found on the underside of the elm leaves. The winged adult is yellowish green and resembles closely the color of the veins of the leaves on which it is found. The antennal segments are tipped with black. The cornicles are short.

The hawthorn aphid, *Aphis crataegifoliae* (Fitch), is sometimes a very troublesome pest on hawthorn trees, often covering the terminal twigs and leaves. Its presence causes the leaves to become curled and distorted. It is usually dark green in color.

The cloudy-winged oak aphid, *Myzocallis bellus* (Walsh), is a small, yellowish species marked with black lines on the sides of the prothorax and with cloudy markings along the anterior margins of both pairs of wings. It occurs on many different species of oaks throughout the country.

The linden aphid, *M. tiliae* (L.), is common on linden trees in both eastern and western parts of the United States. It is yellowish black with clouded wings.

Many species of aphids feed on the edges of the leaves or near the tips and cause the affected parts to be folded over, thus effectively protecting the insects. Others cause conspicuous and characteristic galls to appear, usually on the underside of the leaves.

The chokecherry aphid, *Aphis cerasifoliae* Fitch, curls the leaves of chokecherry, wild cherry, and wild plum wherever it occurs. The wingless forms are pale greenish with dark markings. The winged form is bright green and black.

The manzanita leaf gall aphid, *Tamalia coweni* (Ckll.), rolls the edges of the manzanita leaves, causing conspicuous greenish or reddish, gall-like structures. The aphids living in the galls are brownish or dark greenish with darker markings. The winged migrating forms are dark green and black.

The woolly apple aphid, *Eriosoma lanigera* (Haus.), is best known as a pest of apple trees, but in some regions at least the winter is spent chiefly on the elm trees. In the spring the new elm leaves are attacked and badly curled and distorted. In the early summer this aphid migrates back to the apple trees.

The woolly elm aphid, *E. americana* (Riley), also causes curling and rosettes on the elm trees. The protected pockets thus formed are frequently filled with the aphids and the honeydew which they secrete. Sometimes the aphids become so abundant that they cannot be protected by the folded leaves, and many of them will be found

over the surface. At this time the winged forms are produced and migrate to the apple trees for the summer.

The European elm leaf-curl aphid, *E. ulmi* (L.), overwinters on the elm tree and causes a curling of the leaves in the spring. It migrates to the currants in the summer.

The poplar gall aphids.—There are several species of aphids belonging to the genus *Pemphigus* which pass the winter on poplar and cottonwood trees, producing galls on the leaves or stems in the spring and later migrating to the roots of weeds or cultivated plants for the summer.

FIG. 213.—Elm leaves curled by the wooly elm aphid, *Eriosoma americana* (Riley).

The poplar stem gall aphid, *Pemphigus populicaulis* Fitch, is common on several species of poplar. It makes a conspicuous gall on the petiole at the base of the leaf. This gall is usually reddish in color and has a long, slitlike opening on one side. *P. populitransversus* Riley also forms more or less regular galls on the petioles of poplars and cottonwoods. These galls have transverse openings. The summer hosts are said to be various cruciferous plants.

The poplar twig gall aphid, *P. populiramulorum* Riley, forms galls on the twigs or on the bases of the leaf petioles. The openings are usually longitudinal.

The poplar vagabund aphid, *Mordwilkoja vagabundus* Walsh, is a species that causes large, corrugated galls on the tips of the twigs of several species of poplars. The galls are at first bright green but later turn black and become woody.

The witch hazel cone gall aphid, *Hormaphis hamamelidis* (Fitch). The winter eggs of this species are found on the twigs of witch hazel. The stem mother attacks the lower surface of the young leaves and causes a cone-shaped gall on the upper surface of the leaf with an opening on the lower surface. The next generation migrates to birches where several generations which differ remarkably from each other occur. Later in the fall a generation occurs which migrates back to the witch hazel.

The spiny witch hazel gall aphid, *Hamamelistes spinosus* Shim, attacks the flower buds, causing them to develop into a large, spiny gall within which the second generation is developed. Late in the fall the winged generation migrates to the birches, where an interest-

ing series of generations occurs, the last generation of the birch causing gall-like deformities on the leaves. In these deformities a generation is produced which migrates back to the witch hazel in the early summer.

The elm cockscomb galls produced by *Colopha ulmicola* (Fitch) and *Tetraneura graminis* Mon. are similar galls on the leaves of the elm.

The term "cockscomb" sufficiently describes the appearance of these galls. They open on the underside of the leaves, and the generation that migrates from them passes to certain grasses which form the secondary host.

The dark oak aphid, *Myzocallis discolor* (Monell), is a smoky, winged species which feeds on *Quercus gambellii* and *Q. utahensis* in Utah.

The speckled poplar aphid, *Chaitophoroides populifoliae* (Fitch), is abundant from Utah to Idaho where it feeds on the apical leaves and tender twigs of poplars. The wingless forms are red brown with white, or flocculent patches over the body, length 2.5 mm.

The giant hickory aphid, *Longistigma caryae* (Harris), is one of the largest aphids, the body reaching 6 mm. in length. It is often found clustered on the underside of the limbs of hickory, maple, and other forest trees.

The giant willow aphid, *Lachnus salignus* (Gmel.), is another of our very large, widely distributed aphids. It is characterized by a large, black tubercle near the middle of the back. The body is covered with fine, powdery-white wax. It usually occurs in colonies on the trunks and branches of willows.

The alder blight aphid, *Prociphilus tessellatus* (Fitch), occurs in dense masses on the branches of alder, the flocculent covering often making them very conspicuous.

The beech blight aphid, *P. imbricator* (Fitch), occurs on both the twigs and the leaves of the beech tree and is covered with a conspicuous, downy excretion. These insects have a habit of waving their bodies up and down and excreting a quantity of honeydew when they are disturbed.

For lists of aphids, particularly on conifers, those interested should consult the following references:

Patch, 1912; Wilson and Vickery, 1918; Wilson, 1923; Essig, 1926; Knowlton, 1930; Gillette and Palmer, 1931.

Control of Aphids

Fortunately, aphids are attacked by many predaceous and parasitic enemies which, as a rule, keep them from becoming destructively

abundant. The larvae of syrphid flies, lacewing flies, lady beetles, and other predaceous enemies are very efficient in this work. Parasitic Hymenoptera, especially the braconids, often destroy whole colonies of aphids in a remarkably short time. But under some favorable conditions the aphids may escape their natural enemies for a time at least and increase unduly, and considerable injury may be done to the host trees.

In the forest it is impracticable to use artificial methods of control for these pests, but it is often well worth while to use control measures on park and shade trees.

The soft bodies of these insects make them particularly susceptible to the effects of contact insecticides. Nicotine sulphate used as a liquid spray or as a dust is, as a rule, very effective. For those aphids whose bodies are more or less covered with a mealy or woolly secretion it is often advisable to add a little soap or soap and oil to the spray solution. For those species that curl the leaves it is usually best to spray the tree with oil or lime-sulphur while it is dormant or with a combination of 5 parts of oil and 5 parts of lime-sulphur to 100 gal. of water in an attempt to reach and kill the eggs. After the leaves have been curled by the aphids the only remedial measures is to remove them from the tree. This can, of course, be done profitably only on very small or especially valuable trees.

THE ADELGES AND THE PHYLLOXERA

Two subfamilies of plant lice, regarded by some as two distinct families, are recognized in this group.

The Adelges, family Phylloxeridae, subfamily Adelginae, include a group of species that have been known under the generic name *Chermes*. Unfortunately, it has been necessary to change the name *Chermes* to *Adelges*, and so the subfamily name had to be changed also. Most of the species here described under the generic names *Adelges* and *Pineus* were formerly known under the generic name *Chermes*. *Pineus* has four abdominal spiracles; *Adelges* has five.

The plant lice belonging to this subfamily attack only coniferous trees, and two different species of host trees are used in completing the life cycle. The primary host tree is always a member of the genus *Picea* upon which the insect causes a gall. The insects emerging from the galls migrate to the secondary host which is another conifer. Here the insects live upon the needles and twigs or bark but do not produce galls. There are several generations in the life cycle, usually five, all but one of them consisting of females only, and reproduction is parthenogenetic. In the other generation sexual forms are produced.

Annand (1928), who has recently monographed this group, describes in detail the life cycle of several species.

Cooley's adelges, *Adelges cooleyi* (Gill), like all other Adelges starts its life cycle on the spruce where the winter is passed as immature, minute, dark-brown or black lice which hibernate under bark scales on the twigs near the terminals. Activity starts in early April. The young feed by sucking sap from the tree and after a series of

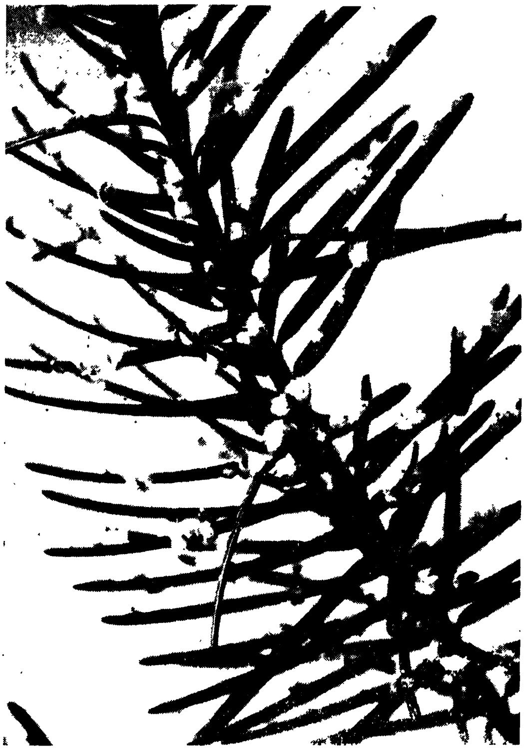

FIG. 214.—Cooley's adelges, *Adelges cooleyi* (Gill.), on Douglas fir. × 2.

moltings become mature stem mothers. The stem mothers secrete a covering of wax under which a large number of eggs are deposited. A week later the eggs hatch, and the nymphs settle down at the bases of the young needles. A gall begins to form and develops rapidly so that at the end of a few days the structure is complete. The galls vary in size from 12 to 75 mm. in length and 12 to 18 mm. in diameter. The gall at first is either green or purple; later it changes to reddish brown. It contains from 30 to over 200 chambers, and each chamber from one to twelve young insects. They develop within the closed gall until June when the gall begins to open, and the nymphs come

forth, settle on the needles, and soon molt for the last time, becoming mature winged forms which migrate to the Douglas fir within a few hours. Upon reaching the new host from 100 to 150 eggs are deposited which hatch in a week. The young settle on the underside of the needles where little development occurs until the following spring when they develop rapidly, becoming fully mature in May. From thirty to sixty eggs are deposited which hatch in about three weeks. This is a dimorphic brood. The winged forms return to the spruce as generation V. The later-developing forms are wingless and remain on

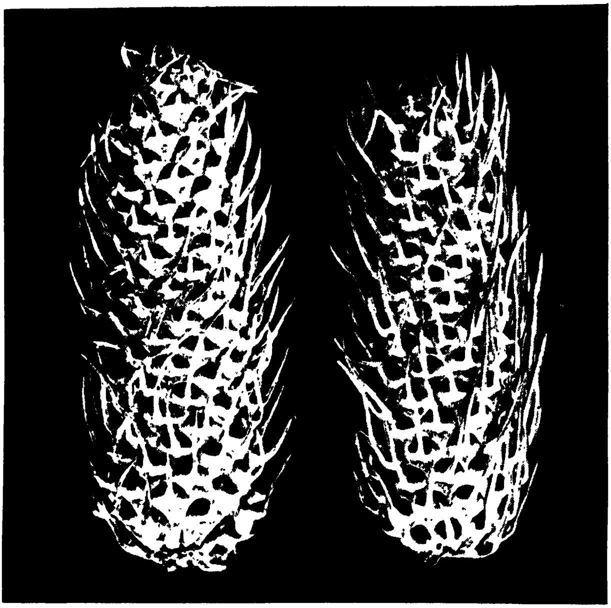

Fig. 215.—Galls caused by *Adelges cooleyi* (Gill.), on blue spruce.

the Douglas fir until spring when they give rise to a summer brood on the fir needles. Those returning to the spruce settle on the needles and deposit a few eggs (ten to twenty-five) which presumably give rise to several forms, the females of which deposit a single egg which produces a nymph destined to be a stem mother in the spring.

The galls formed on the spruce trees destroy the terminal buds, often deforming the growing tree. This may at times be of considerable economic importance, as spruce of all ages may suffer severely from the attacks of this Adelges. The galls on the young trees kill the leaders and terminal shoots, deforming and greatly retarding the growth of the young trees. The vigor of the old trees may be so greatly reduced that other enemies such as *Dendroctonus* may complete the work of destruction. As a rule, however, the galls are not

usually abundant enough to be of a special interest in the forest. Ornamental trees often suffer severely on account of the attacks of this pest. On the Douglas fir the most serious injury results when young trees or trees used for ornamental purposes are attacked. The aphid causes the leaf to turn yellow and finally to drop. Badly infested young trees lose all of their older needles in this way. Even in the forest when these insects are abundant they may cause many of the leaves to turn brown and fall prematurely.

This species occurs on several kinds of spruce throughout the Rocky Mountain region and on the West Coast. The intermediate host is the Douglas fir.

When control measures are deemed advisable in nurseries and on ornamental trees an application of nicotine sulphate is usually sufficient to control the pest.

The spruce gall adelges, *Adelges abietis* (L.).—This insect causes conelike galls at the base of new growth on various species of spruce. The galls are 15 to 30 mm. in length and greenish in color with a reddish line around the closed mouths of each cell.

In the United States the Norway spruce is the principal host for this species, but it occasionally causes damage to Colorado blue spruce and to white and red spruce. In Europe some authorities claim that it sometimes migrates to the larch. There are two generations each year. The winter is passed as minute, naked, blackish or greenish nymphs in the crevices about the bud scales. Early in the spring these move out on the twigs where they begin to feed and secrete a white, cottony mass which covers them and the eggs that they lay. The young from these eggs soon begin to feed in colonies at the base of the new growth. Their feeding causes the bases of the leaves to become swollen, and the pineapple-like galls are thus produced. If the galls are abundant, they may check the growth of the twigs, or the twigs may be badly distorted or killed.

This species is well-distributed throughout the East. It is particularly troublesome in nurseries and on park and other ornamental trees. Where control measures are advisable the galls may be picked from small trees during the winter, or the trees may be sprayed with an oil spray during the early spring or with nicotine sulphate when there is new foliage in the trees. Lime-sulphur is also recommended as a dormant spray (Gambrell, 1934).

Adelges laricatus (Patch) closely resembles *A. abietis* (L.) It occurs on *Picea* with *Larix* as the alternate host. It is found in the Northeastern and North-central states.

The woolly larch adelges, *A. strobilobius* (Kalt.), formerly known as *C. consolidatus* Patch, has *Picea* for definite hosts and *Larix* as

intermediate hosts in the New England states and in Canada. *A. oregonensis* Ann. is recorded from Oregon and Washington on *Larix*. *A. diversis* Ann. was collected on *Larix* in Oregon.

A. piceae (Ratz.) often causes gnarled or distorted growth on *Abies nobilis* and other firs. Some trees may be killed. It occurs on both the East and West coasts. *A. nusslini* Borner is a very closely related species with much the same distribution. *A. tsugae* Ann. is reported from California, Oregon, and possibly British Columbia.

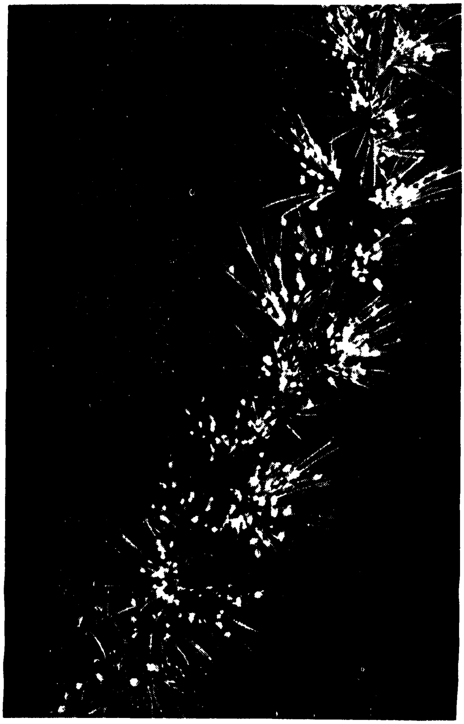

FIG. 216. *Adelges laricialus* (Patch). × 1. (*Photo by Slingerland.*)

The pine bark adelges, *Pineus strobi* (Hartig).—Annand, apparently with considerable hesitation, uses this technical name for the species that has been so long known as *Chermes pinicorticis* Fitch and more recently as *A. pinicorticis* (Fitch). The common name, however, serves to identify the species. This insect infests several species of pines. The northern white pine is the favorite host. The trunks and larger limbs of infested trees often appear as if whitewashed on account of the white, flocculent, woolly secretion which covers the insects. The aphids themselves are dark brown and are sometimes so abundant as seriously to reduce the vitality of the trees. Natural

stands of trees are seldom very seriously infested, but ornamental plantings often become very unthrifty and unsightly and may even be killed when this aphid is abundant. In city parks and other places where a hose and a good force of water are available it is advisable to wash these aphids from the trees by turning a powerful stream on them. Nicotine sulphate, miscible oils, and other insecticides may be used, but it is always necessary to use a great deal of force in applying the spray in order to make the insecticides penetrate the woolly secretion that covers the insects.

The pine leaf adelges, *Pineus pinifoliae* (Fitch).—This species is widely distributed, occurring in many places from coast to coast where its two host plants are growing. Early in the summer the winged forms may appear in great numbers on the needles of *Pinus strobus* in the East and on *P. monticola* in the West. Each female soon lays about 100 eggs, and the young from these feed on the new growth of the trees. When abundant they may do considerable damage especially to young trees.

The gall-forming generation occurs on *Picea mariana* and *P. rubra* in the East and on *P. engelmanni* and other spruce in the West. The galls look so much like cones that they are often mistaken for a normal growth on the trees.

Pineus floccus (Patch) has the same host trees as *P. pinifoliae* in New England. Galls of *P. similis* (Gill.) have been collected on various kinds of spruce in New England, Colorado, and Oregon.

Other species of *Pineus* listed by Annand are *P. boycei* Ann. from Montana and Oregon on *Picea engelmanni; P. borneri* Ann. from California on *Pinus sylvestris; P. coloradensis* (Gill.) throughout western United States on various pines; *P. cembrae* (Chol.) from Michigan on *Picea* sp.; *P. engelmanni* Ann. from Oregon on *Picea engelmanni*.

THE PHYLLOXERA

To the Phylloxera, subfamily Phylloxerinae, belong a number of species that closely resemble typical aphids and are found on broad-leaved forest trees especially in the eastern United States. Most of the described species occur on various kinds of hickory where they produce characteristic galls on the leaves or stems. Two have been found in galls produced by *Pemphigus*. *Phylloxera castaneae* (Hald.) causes distortions of the chestnut leaves. Those occurring on oaks do not seem to produce galls but may cause conspicuous spots on the leaves. Six species are recorded by Duncan (1922) as occurring on oaks in the West.

The gall-making species of this group hatch from the overwintering eggs as soon as the buds start to burst, and the new growth starts in the spring. As soon as the young aphids begin feeding on the new leaves or shoots, the galls begin to develop. These stem mothers begin to lay eggs within the galls about 20 days after hatching. The winged migratory females begin to leave the galls about 20 days later. These lay the eggs from which the sexual generation appear about 10 days later. The overwintering eggs are deposited in cracks or crevices or other protected places on the trees.

The hickory gall phylloxera, *Phylloxera caryaecaulis* Fitch, is widely distributed. It attacks various kinds of hickory, occurring sometimes on the leaves or petioles but more commonly on the new shoots where it causes galls of considerable size which may distort or kill the young twigs. *P. caryaefoliae* Fitch is common on *Hicoria glabra* from the Atlantic Coast to Illinois and as far south as Washington. *P. perniciosa* Perg. is one of the most destructive species in Maryland, Virginia, and Pennsylvania.

FIG. 217.—Immature stage of *Aleyrodes kelloggi* Bemis. Greatly enlarged.

WHITE FLIES

White flies or aleyrodids, family Aleyrodidae, are minute insects with a wing expanse of about 3 mm. The wings of many species are covered with a whitish, flourlike powder. The immature stages often look much like scale insects and are frequently mistaken for such. The larvae are often covered or surrounded by waxy secretions, making them beautiful and conspicuous objects on the dark surface of the leaves.

Although some members of this family are sometimes serious pests on citrus trees and in greenhouses, they are of little or no importance in the forest where they are sometimes seen on maple, oak, and other trees.

THE SCALE INSECTS

The scale insects, family Coccidae, include some of the most important pests with which the horticulturist has to deal. Almost all kinds of fruit trees and shrubs are subject to the attacks of one or more species of these insects. Most of the shade and ornamental trees may also be seriously affected at times, and forest trees, while not often killed by the scale insects, may be so seriously weakened

that they quickly become a prey to bark beetles or other pests. Young trees, particularly in nurseries or in areas being reforested, are very susceptible to injury from various scale insects.

In the forests little or nothing in the way of control measures can be recommended, for the location and size of the trees and the larger areas usually affected make it impracticable to deal with the scale insects in the usual manner. Fortunately, practically all of the scale insects affecting our forest trees are heavily parasitized by small chalcids and attacked by other natural enemies and are thus, except under unusual conditions, kept from becoming too destructive. But the serious results often following the attacks of some species of scale insects on shade trees make control measures imperative. Spraying with some of the oil emulsions while the trees are dormant is usually recommended.

Experiments made within the past few years have demonstrated that most of the conifers can be sprayed with oil emulsions with no harm to the foliage. Very satisfactory results have followed the application of highly refined oils and emulsions in controlling the pine tortoise scale on Jack pine and Scotch pine.

The insects usually included in this family differ so much in their appearance and habits that it is difficult to give any set of characteristics that will include all of them. Some, like the San Jose scale and other typical members of the group, have their soft bodies covered over with a scale made up largely of a secretion in which is included the molted skins of the younger stages. These scaly coverings may be round or nearly round, as in the genus *Aspidiotus*, or they may be somewhat elongate and situated at the end of the more conspicuous part of the scale that covers the eggs. In the oyster-shell scale, genus *Lepidosaphes*, the whole covering is brown and horny. In the pine-needle scale, genus *Chionaspis*, it is whitish and softer.

The members of the genus *Lecanium* and related genera do not secrete a scalelike covering, but the dorsal body wall becomes more or less hardened, sometimes quite convex, and thus forms a protection for the developing eggs and the young. Some members of this group, genus *Pulvinaria* and others, secrete a cottony or waxy ovisac which is often quite conspicuous.

The mealy bugs, genus *Pseudococcus*, and some related genera, are almost the only members of the family that retain the typical insect-like appearance throughout life, and even some of these are quite disguised by the cottony or waxy secretions which are developed for the protection of the eggs.

Specific identifications except in some of the more common or striking forms are difficult to make by one who is not a student of

the group, but the following brief notes may help him to recognize some of the commoner species.

Scale Insects on the Needles or Branches of Conifers

The genus Chionaspis includes several species often occurring in destructive numbers on conifers as well as on deciduous trees. The scales are elongated or pear-shaped, usually white or grayish in color, with the yellowish exuviae at one end. The scales of the males are smaller and often longitudinally ribbed.

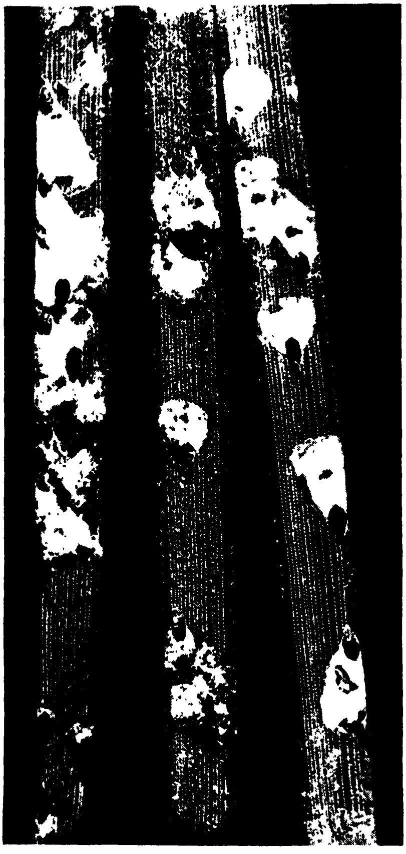

Fig. 218.—The pine-needle scale, *Chionaspis pinifoliae* (Fitch). × 2.

The pine-needle scale, *Chionaspis pinifoliae* (Fitch), is the most common and widely distributed species belonging to this genus. It occurs on nearly all species of pines and on some species of fir, cedar, and spruce. Young pine trees are often much weakened, sometimes killed when seriously infested. Spraying with nicotine or a light oil emulsion soon after the eggs hatch in the early summer is recommended.

A few species of the genus *Aspidiotus* attack coniferous trees.

The hemlock scale, *A. pini* Comst., is a widely distributed species occurring on various pines and on fir and hemlock. The scales are circular and nearly black. They are sometimes abundant enough on the needles of young pine trees to cause the death of the trees. Heavy infestations on ponderosa-pine reproduction have caused widespread killing of second-growth trees in California and Oregon. The natural enemies usually keep them from becoming destructively abundant. *A. glanduliferus* Ckll. attacks the bark of Douglas fir in California. *Aonidia shastae* Colm. is found on the leaves of *Sequoia sempervirens* in California.

The juniper scale, *Diaspis carueli* Targ., infests juniper, arborvitae, and some cedar and cypress. It may be found on the twigs,

cones, or leaves of the infested plants. It is widely distributed. The scale of the female is circular, grayish, and quite flat. The scale of the male is much smaller, elongated, and white.

The spruce bud scale, *Physokermes piceae* (Schr.), is a more or less globular, brownish scale found at the base of the small branchlets on the spruce where it resembles, somewhat, an abnormally developed bud. It secretes an abundance of honeydew and gives the trees a very untidy appearance.

The Monterey pine scale, *P. insignicola* (Craw), is a related species occurring on pines in California. *P. coloradensis* Ckll. is found

FIG. 219.—The Monterey pine scale, *Physokermes insignicola* (Craw), on Monterey pine. About natural size.

on spruce and fir in Colorado, and *P. concolor* Colm. on fir in California and Oregon.

The irregular pine scale, *Toumeyella pinicola* Ferris, looks much like the Monterey pine scale and is often associated with it, but it is softer, paler in color, and more irregular in shape. *T. pini* (King), *T. corrugatum* Thro., and *T. numisaticum* Pett. & McDon. occur on pine in the East.

The woolly pine scale, *Pseudophilippia quaintancii* Ckll., affects the tender growth of the southern pitch pine. The conspicuous white woolly scale suggests the popular name "pitch-pine wool."

The genus Eriococcus includes a number of species in which the females and their eggs are enclosed in oval white feltlike ovisacs. *E. araucariae* Mask. has been introduced with the araucarias and occurs where these are grown. *E. gillettei* Tins. is found on red cedar in Colorado and New Mexico and on juniper in Oregon.

The cottony cypress scale, *Ehrhornia cupressi* (Ehr.), lives in the cracks in the bark of certain cypress and cedars in the West. Its

presence is indicated by the conspicuous, white, cottony secretion which is to be seen on the branches or trunks of infested trees. It is sometimes very destructive on Monterey cypress in California where this tree is used extensively for hedges and other ornamental purposes. Its native host is probably the incense cedars in the Sierra Nevada Mountains. A 12½ per cent solution of a high-grade miscible oil is the spray recommended. To obtain complete control it is necessary to spray twice, once in August and once in the latter part of September.

The golden mealy bug, *Pseudococcus aurilanatus* (Mask.), is covered with tufts of yellowish, waxy secretion. It is often a serious pest on araucaria in California. The oil-washing-powder-nicotine spray is used in controlling it.

The cypress mealy bug, *P. ryani* (Coq.), is sometimes destructively abundant on cypress. It occurs also on arborvitae, incense cedar, and a few other hosts.

The redwood mealy bug, *P. sequoiae* (Colm.), is found on redwood and cypress sometimes very abundantly.

The silver spruce phenacoccus, *Phenacoccus minimus* Tins., is reddish pink and partially enclosed in the fluffy, coarse, filamentous ovisac. It occurs at the base of the needles on the silver spruce in Colorado, sometimes killing them.

The cypress puto, *Puto cupressi* (Colm.), is an olive-brown mealy bug with the body sparsely covered with white, powdery wax. It is found on the California coast on Monterey cypress, Monterey pine, and redwoods.

The cypress xylococcus, *Xylococcus macrocarpae* Colm., occurs on Monterey cypress and incense cedar in California. The white, waxy threads look like white hairs on the bark of the trees. Young cedars may sometimes suffer from the attacks of this insect. *X. quercus* Ehr. is found on the live oak and black oak in California.

The piñon needle scale, *Matsucoccus acalyptus* Herb., is 2 or 3 mm. long, flat, elongate oval, and the wrinkled body is brownish or blackish in color. It is found exposed on the needles of the single-leaf piñon pine in California where it sometimes does considerable damage.

The three-leaf pine scale, *M. fasciculensis* Herb., lives between the leaves or in the sheath of the digger and ponderosa pines in California. It is somewhat larger than the preceding species. *M. matsumurae* (Kuw.) is reported as doing considerable damage to *Pinus virginia* and *P. rigida* on Long Island. As it lives in pits or galls under the surface of the bark or twigs, its presence is difficult to detect.

Scale Insects on Deciduous Trees

The San Jose scale, *Aspidiotus perniciosus* Comst., was for many years the worst pest of orchard and shade trees and many other plants in all parts of the United States. Whole orchards were quickly killed, and shade and ornamental trees often suffered the same fate. This insect is now much less abundant in most of the regions where it was once so destructive, but it may at times occur in such numbers as to make control measures necessary. The insects themselves are yellowish in color, but the protecting scaly coverings are grayish, circular, and so small that it is hard to detect their presence on the bark of the tree. The scales of the males are the same color but smaller and narrower.

The greedy scale, *A. camelliae* Sign., is much more convex and lighter in color. The exuviae are near the edge of the scale. It occurs on many wild and cultivated trees and shrubs.

The oleander scale, *A. hederae* (Vall), is lighter in color with the exuviae central. It is a general feeder.

Putman's scale, *A. ancylus* (Putn.), has a large, gray, circular, flat scale. Its host list includes many deciduous trees. Its presence on the bark is hard to detect.

The walnut scale, *A. juglans-regiae* Comst., attacks walnuts, locusts, maple, and many other hosts. *A. ostreaeformis* Curtis is found on birch, maple, oak, and a long list of other trees.

All of the species just named are widely distributed, occurring in most of the states from the East to the West Coast.

Other species belonging to this genus and found on deciduous shade or forest trees in the Eastern and Middle Western states are *A. comstocki* Jn., *A. forbesi* Jn., *A. osborni* New. & Ckll., *A. ulmi* Jn., and *A. uvae* Comst. *A. aesculi* Jn. occurs on buckeye in California and New York. *A. townsendi* Ckll. is reported from ash in Arizona. *A. densiflorae* Brem. is found on tan oak in California.

Several species of the genus *Chionaspis* attack deciduous trees. **The scurfy scale,** *C. furfura* (Fitch), is quite a common pest on deciduous trees, attacking a wide range of plants all over the United States and being particularly injurious in the eastern states.

The black willow scale, *C. salicis-nigrae* (Walsh), is widely distributed and is found on willow, poplar, tulip, maple, and other trees and shrubs.

The elm scurfy scale, *C. americana* Jn., occurs on elm throughout the Eastern and Middle Western states.

Other species belonging to the genus *Chionaspis* and more or less common on deciduous trees are *C. caryae* Cool. on hickory and *C.*

lintneri Comst. on alder, willow, and *Cornus* in the East. *Chionaspis longiloba* Cool. is reported from Texas and New York on cottonwood. *C. quercus* Comst, is common on various species of oak in California and New Mexico.

The oyster-shell scale, *Lepidosaphes ulmi* (L.), attacks almost all kinds of deciduous trees and shrubs in all parts of the United States. The scales are shaped like an elongated oyster shell. The scale of the male is smaller than that of the female. They are often so abundant as to form a brownish crust on the bark of their host, and frequently kill the twigs and limbs and sometimes the whole tree. These scales may be controlled by using a combination of summer oil and nicotine which should be applied just after the overwintering eggs hatch and the young begin crawling.

FIG. 220.—The oyster-shell scale, *Lepidosaphes ulmi* (L.). × 1.

The obscure scale, *Chrysomphalus obscurus* (Comst.), is a very small, circular, dark-gray scale which sometimes causes the death of twigs and branches of oak, hickory, and some other trees in the eastern and southern states.

The campor scale, *Pseudaonidia duplex* (Ckll.), has become a very serious pest on shade trees and other plants in Louisiana. The scale of the female is circular, moderately convex, and dark brown in color. The large, orange-colored exuva is situated near one edge of the scale. The presence of only a few of these insects may quickly kill a limb, and some trees may be killed within a few months after the first attack. This scale is said to be very susceptible to cyanide-gas fumigation. It may also be controlled by spraying dormant trees with oil emulsions.

The genus *Lecanium* and related genera include a number of species some of which may become destructively abundant on certain deciduous trees.

The European fruit lecanium, known in the west as the **brown apricot scale,** *Lecanium corni* Bouche, is the most widespread and destructive member of this group. It is of most importance as a pest of fruit trees but is common on many shade and ornamental trees and shrubs. The size, shape, and color vary so much that it has been

described under many specific names. Typically it is almost hemispherical, being a little longer than wide. The surface is usually smooth and shiny and brownish in color. The winter is passed as a very small or half-grown, very flat insect on the limbs or twigs of the host plants. Miscible oils, applied during the dormant season, are used for controlling this pest.

The black scale, *Saissetia oleae* (Bern.), is another very important pest, being responsible for a loss of more than $2,000,000 annually to the citrus-fruit growers of California. It attacks many shade trees and other ornamental trees and shrubs. The adult females are hard, black, nearly hemispherical, and marked with two more or less distinct transverse ridges and one longitudinal ridge on the dorsal side. These ridges form the letter H.

The soft brown scale, *Coccus hesperidum* L., is a common pest on many greenhouse and ornamental plants and is often abundant on shade trees. It is soft, elongated, only slightly convex, and brownish or pale yellowish in color.

The oak lecanium, *Lecanium quercitronis* Fitch, occurs on various shade trees throughout the East but is most abundant on oaks in the southern and western states. It is very convex, light brown, sometimes marked with darker markings.

The black-banded scale or the **terrapin scale,** *L. nigrofasciatum* Perg., and several others belonging to this group, are found on elm, maple, and other shade trees.

FIG. 221. The cottony maple scale, *Pulvinaria vitis* (L.), on maple. Slightly enlarged.

The cottony maple scale, *Pulvinaria vitis* (L.), belonging to the same group as the lecaniums but differing from them in developing a conspicuous, cottony egg sac at the posterior end of the body, occurs principally on the maple, but it may infest many other trees and shrubs in various parts of the United States.

The maple leaf scale, *P. acericola* Wal. & Riley, looks much like the preceding species, but the adult females with their conspicuous white ovisac are on the leaves more commonly than on the twigs.

The maple phenacoccus, *Phenacoccus acericola* (King), is frequently very abundant on the undersides of sugar maple leaves in midsummer.

The insects and their eggs are covered with a white, cottony sac. The males migrate to the trunk, where the white secretion that covers them gives the trunk of a badly infested tree a grayish or whitish appearance. As oil sprays are apt to injure sugar maple trees, it is best to use a nicotine solution when control measures become necessary.

The tulip tree scale, *Toumeyella liriodendri* (Gme.), passes the winter as small, flat young insects on the branches of tulip trees. During the early summer they become large, hemispherical, brown scales nearly 6 mm. in diameter. They have an unpleasant odor. Spraying with lime-sulfur or miscible oil while the trees are dormant is recommended.

Fig. 222. The European elm scale, *Gossyparia spuria* (Mod.). × 2.

The European elm scale, *Gossyparia spuria* (Mod.), is the best known scale insect attacking the elms. The reddish-brown bodies, surrounded by white, cottony fringes, are familiar objects on many species of elms. The honeydew which they secrete causes the trees to become black and smutty, and walks or seats under the infested trees are covered with this disagreeable secretion. Infested trees should be sprayed during the dormant season with one of the oil sprays. A combination of 5 parts of winter oil and 5 parts of lime-sulphur to 100 gal. is recommended by some. In some cities a powerful stream of water from a fire hose is directed against the trees about the time that the leaves begin to unfold. This will dislodge the females which are swollen with eggs at this time and will clear much of the small, dead brush from the trees.

The beech scale, *Cryptococcus fagi* Bar., feeds on the bark of beech. The body is covered with wool-like threads and when the insect is abundant the bark is covered with white, woolly patches. This scale insect seems to open the way for bark-infecting fungi (*Nectria*) which seriously injure and often kill the beech trees. It occurs in the New England states and in Nova Scotia and New Brunswick.

The birch xylococcus, *Xylococcus betulae* Perg., is found hidden away in crevices or rough places on the bark of birch in the eastern states, and what is probably the same species occurs in alder in California and Oregon. The presence of the insect, which is dark red, is indicated by the white, waxy threads which extend from the posterior end of the body.

The cottony cushion scale, *Icerya purchasi* Mask., may be readily distinguished by the conspicuous, fluted egg sac which is often more than twice as long as the reddish or yellowish body of the female. It was introduced from Australia many years ago and in a very short time threatened to destroy the citrus-fruit industry in California. Fortunately, investigators were able to find several natural enemies which were feeding on this insect in its native home. These were sent to California, and some of them, especially a small black-and-red lady beetle, commonly known as the vedalia, *Rodolia cardinalis* (Muls.), became well-established here and soon had the pest under control. The cottony cushion scale attacks many native trees and shrubs as well as cultivated varieties, but the lady beetles usually find a colony of the scales before they become well enough established to be of any economic importance, and they hold them in check. A small black parasitic fly, *Cryptochaetum iceryae* (Will.), is often still more important in controlling local outbreaks of the cottony cushion scale.

The mealy bugs are among the most serious pests of many of our trees, shrubs, and other ornamental plants. A few species may be found on some of our forest trees, but there is no record of their ever being very abundant. Some of the general feeders, such as the citrophilus mealy bug, *Pseudococcus gahani* Green, in the West; and Comstock's mealy bug, *P. comstocki* (Kuw.), in the East may occur in considerable numbers on various shade trees where their secretions make the trees unsightly and disagreeable.

The citrophilus mealy bug is covered with a white, waxy secretion with four rows of darker spots along the dorsal side, the median rows being most conspicuous. The lateral filaments are slender and short. There are two pairs of anal filaments, the outer pair short and the inner pair about one-fourth or one-third the length of the body. Comstock's mealy bug does not have the rows of darker spots on the dorsum; the lateral filaments are somewhat longer and stouter; and the anal filaments are from one-third to one-half the length of the body. This species is the most serious pest of the umbrella catalpa in some of the eastern states. Not only does the honeydew give the tree a dirty appearance, but the tree suffers from the loss of sap and because the presence of a number of the pests on the limbs and twigs causes the formation of galls which distort and weaken the limbs.

Many other hosts are attacked, but the galls are recorded only from the catalpa.

It is difficult to control the mealy bugs with any of the ordinary sprays, as the waxy covering offers so much protection. A good miscible oil will reach most of them, however. A successful spray for controlling the citrophilus mealy bug is made by using 1 gal. of miscible oil, and 7½ lb. of washing powder, and ½ pt. of nicotine (Blackleaf 40) to 50 gal. of water. Hough recommends that catalpa trees infested with Comstock's mealy bugs be pruned vigorously when dormant, thoroughly cleaned, and sprayed with lime-sulfur or oil. In August the center of the head of each tree should be thoroughly cleaned with a stiff wire brush in order to remove the females which are getting ready to produce the third, and most troublesome, generation.

FIG. 223.- *Kermes nigropunctatus* Ehr on oak. X 2.

Oak trees are attacked by a number of different species of scale insects. While these are seldom or ever of much economic importance, some of them may be mentioned because they are more or less common.

The genus Kermes includes many species of gall-like insects which are to be found on various species of oaks. The minute, mitelike young begin feeding on the tender twigs or on the foliage of the tree. The winter is passed in the crevices in the bark, and in the spring the females develop into a firm-walled globular insect which may be found on the smaller twigs, leaf petioles, or along the midrib of the leaf. Their presence on the leaves causes more or less distortion of some species of oaks. The kermes are seldom abundant enough to be of any importance, but they may sometimes injure or even kill some of the twigs. A good miscible oil applied just before the leaf buds open should kill most of the overwintering females.

The classification of genus *Kermes* is in a very unsatisfactory condition. The descriptions of the species all read much alike, and the seventeen species listed by Fernald as occurring on oaks in the United States doubtless include several synonyms. Others have been

described later. No attempt to describe the species is made here, but a few notes on distribution may be of interest.

Kermes galliformis Riley and *K. quercus* (L.) are reported from nearly all parts of the United States. *K. nigropunctatus* Ehr. and *K. cockerelli* Ehr. are the most common California species. *K. shastensis* Ehr. infests live oak in the Mount Shasta and Tahoe regions, and *K. austini* Ehr. occurs in southern California. *K. arizonensis* King and *K. ceriferus* Ehr. occur in Arizona. *K. gillettei* Ckll. is found in Colorado, New Mexico, and Texas. *K. boguei* Ckll. is reported from Oklahoma. *K. concinnulus* Ckll. is recorded from Kansas. *K. andrei* King, *K. pubescens* Bogue, and *K. trinotatus* Bogue extend their range from the East Coast to the Mississippi Valley states. *K. kingii* Ckll., *K. nivalis* King & Ckll., *K. perryi* King, and *K. pettiti* Ehr. are more eastern in their distribution.

The pit-making oak scale or golden oak scale, *Asterolecanium variolosum* (Ratz.), is a small, round or oval, yellowish-green or golden scale insect which causes little pits on the smaller limbs and twigs of various species of oak throughout the United States.

Ehrhorn's oak scale, *Cerococcus ehrhorni* Ckll., is a small, bright-red insect covered with a whitish secretion. It occurs most commonly on the lower sides of the limbs of live oak in California where the grayish fungus associated with it often gives the badly infested limbs the appearance of having been whitewashed.

The woolly oak scale, *Trionymus villosa* (Ehr.), is found in the cracks and crevices of *Quercus agrifolia* in California. The young are covered with a white, powdery wax, and the adults are enclosed in a thin, oval, white sac.

The gall-making coccid, *Olliffiella cristicola* Ckll., forms a conical, acorn-like gall on the underside of leaves of *Quercus wrightii* in New Mexico.

Eriococcus quercus (Comst.) is common on various species of oaks in both eastern and western states.

THE CICADAS

The cicadas, family Cicadidae, are well-known insects characterized by their clear, thin, membranous wings; prominent eyes; three ocelli; short, bristle-like antennae; and three-segmented tarsi. The males are provided with complicated sound-producing organs, and the shrill continuous song of the cicadas, or locusts as they are sometimes called, is familiar to all. Because these insects are common in the summer and at harvest time they are often called harvest flies.

The periodical cicada, *Magicicada* (*Tibicen*) *septendecim* (L.), often known as the "seventeen-year locust," is widely distributed and

sometimes of considerable economic importance. The female, when laying her eggs, makes a series of slits in the branches or twigs of trees, often killing the twig or so weakening the small branches that they are broken by the wind. Soon after hatching, the young drop to the ground and make their way to the roots where they feed for seventeen years. In May or June of the seventeenth year the nymphs come to the surface and crawl for a short distance up the trunk of the tree or some other object, and the adult cicada issues. Another form takes thirteen years to complete its development; still others take much less time. About seventy-four species of cicadas belonging to sixteen different genera occur in this country. More than twenty distinct broods of the periodical cicada are known, and their distribution has been traced out. In some localities two or more broods coexist and issue in different years; so seventeen years does not always intervene between one outbreak and another.

Little or nothing can be done to prevent the damage due to the nymphs' feeding on the roots of trees, for they are usually far below the surface of the ground. The harm that they do is negligible, except perhaps on young trees or in nurseries.

As it is the young trees or nursery stock that suffer most on account of the punctures made by the cicada when laying her eggs, it is advisable not to do extensive planting of any trees within a period of two or three years before the cicadas are scheduled to appear in the region where the planting is to be done.

SPITTLE INSECTS OR FROGHOPPERS

The nymphs of the spittle insects, family Cercopidae, are readily recognized by the fact that they are found on their host plant surrounded by a white, frothy mass which resembles spit. Because it was formerly supposed that this frothy material was voided from the mouth of tree frogs it was known as "frog spittle," and when the insects were found in it they were called spittle insects or spittle bugs. The insects are well-protected by this secretion which comes largely from the anus. The adults are known as froghoppers. The prothorax is not prolonged over the back, as in the next family; the antennae arise from in front of the eyes; and the tibiae have one or two stout teeth before the tip which is crowned with short, stout spines.

Spittle insects are found on many different plants including some of our forest and shade trees. The pine spittle insect, *Aphrophora parallela* Say, often occurs in great numbers on pines in the East, sometimes killing young trees. *A. permutata* Uhler, is often common on small Douglas fir and grand-fir seedlings. Several other species such as *A. saratogensis* Fitch and *Clastoptera proteus* Fitch occur commonly

on pines in the East. *C. obtusa* Say is widely distributed, attacking a variety of trees and shrubs in the West as well as in the East.

THE TREE HOPPERS

The family Membracidae includes a number of interesting insects known as tree hoppers. The name is somewhat misleading for many species are found on weeds and grasses as well as on shrubs and trees. In the members of this family the prothorax extends back over the abdomen, and it is usually extended upward and sidewise, often giving the insect a very characteristic and striking appearance. Tree hoppers suck the juices from their host plants and in this way may do some damage when abundant, but the greatest injury occurs when the female makes the egg punctures in which she lays her eggs. The punctures are similar to those made by the cicada but much smaller. When abundant they may injure young trees by weakening or killing twigs or small branches.

The buffalo tree hopper, *Ceresa bubalis* Fab., is one of the most common and widely distributed species. It is bright green in color with the underside yellowish. The lateral prolongations of the prothorax suggest the horns of a buffalo. This insect occurs on many different wild and cultivated trees and shrubs but is seldom abundant enough to make control measure necessary. It feeds principally on annuals beneath trees used in ovipositing.

The oak tree hopper, *Platycoris vittata* (Fab.), varies in color from olive to sea-green or bronze, finely marked with red spots. The variety *quadrivittata* (Say) is pale bluish with conspicuous red stripes. The nymphs are black with yellow and red markings. These insects are sometimes found in considerable numbers on various species of oak and may cause considerable alarm especially when colonies of the conspicuous young are found together on the oak twigs or branches.

THE LEAF HOPPERS

The leaf hoppers, family Cicadellidae, or sharpshooters, as they are sometimes called, are more common and abundant than the tree hoppers. The body is usually long and slender, and the prothorax is not unusually developed. The hind tibiae are long and armed with a row of spines on each margin. These insects can leap for considerable distances, and they fly readily.

On account of their numbers they are often serious on many field and truck crops, not only because they suck the sap from these plants, but because some species carry disease-producing organisms which cause curly leaf, tipburn, blight, etc. Fruit and shade and ornamental trees are often attacked. The feeding punctures cause

whitish spots on the leaves, and when they are abundant the leaves may dry and drop from the tree.

The apple leaf hopper, *Empoasca mali* (LeBaron), an important pest in orchards, is often abundant on many shade trees as well. This insect is about 3 mm. long, pale yellowish green, and has six or eight white spots on the pronotum. Light summer oils or nicotine sulphate or soap washes may be used for killing the nymphs when they become too abundant.

JUMPING PLANT LICE OR PSYLLIDS

Because they resemble the aphids or plant lice somewhat, the members of the family Chermidae are called jumping plant lice. Some species look much like miniature cicadas. The largest are only about 7 mm. long, and some are less than half that size.

The laurel psyllid, *Trioza alacris* Flor., an imported species, causes a curling and thickening of the edges of laurel trees and thus does some injury. The insects may be controlled by spraying in the spring and early summer with miscible oil.

The hackberry gall psyllid, *Pachypsylla celtidis-mamma* Riley, causes galls to form on the underside of the leaves of hackberry.

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CHAPTER XI

SOME OTHER ORDERS OF INSECTS AND THE MITES

We have already discussed, somewhat in the order of their importance, the different groups of insects that often cause serious losses in the forests. There remain still a few other insects, representatives of different orders, which may, under certain conditions, become of considerable economic importance.

To the order Diptera belong many of our most familiar insects such as the houseflies, mosquitoes, black flies, punkies, horseflies, and others that are important pests of man and domestic animals. To this order belong, also, some groups of flies that are parasitic or predaceous on many kinds of insects, and these often may be important factors in the control of some of the forms that are injurious in the forests.

THE GALL GNATS

Most important from the forester's viewpoint are the gall gnats or gall midges belonging to the family Cecidomyiidae. (The name Itonididae is sometimes used.)

This is a large family of very small, frail flies with broad wings and long, slender antennae. The adult flies, or midges, are so small that they seldom attract attention. The larvae are mostly plant feeders, many producing characteristic galls or distortions on the leaves or twigs of their host plants. Others live in the seeds, trunk, or even the pitch that exudes from wounds.

Plant galls are caused by other dipterous larvae and by members of the orders Hymenoptera, Coleoptera, Lepidoptera, and Hemiptera. Galls caused by midges may generally be recognized by the enclosed larvae which are usually narrow, oval or lanceolate in form, and whitish or yellowish in color. The larvae of the members of this family possess a bifid, chitinized process in the anterior ventral part of the body. This is known as the "breastbone."

Not all cecidomyia produce galls.

The life cycle of the gall midges usually occupies about one year, but some species have more than one generation a year.

E. P. Felt has done more work with the Cecidomyiidae and has written more extensively on this family than has any one else. In

compiling the following list extensive use has been made of his "Key to American Insect Galls" and other papers. The species are listed here according to their host plants.

On Pines

The Monterey pine midge, *Thecodiplosis piniradiatae* (Snow & Mills), is the most important member of this group in the West. The head of the adult midge is blackish with long, slender, yellowish or brownish-yellow antennae. The mesonotum and abdomen are dark reddish brown. The ovipositor is usually protruded until it is as long as the rest of the body.

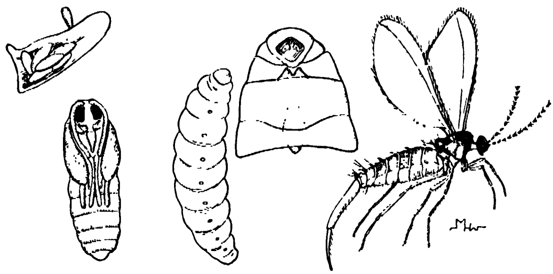

Fig. 224.—The Monterey pine midge, *Thecodiplosis piniradiatae* (Snow and Mills). × 15. Eggs in upper left corner; pupa, larva, × 25, "breastbone" of larva, adult female. (*Kellogg's American Insects.*)

Late in December or in January the first midges may be seen swarming around the pine trees. They continue to issue until about the middle of March. The female thrusts her long ovipositor between the scales of the terminal buds and lays from two to twenty-four eggs in a mass. The eggs are light yellow when first deposited but soon turn to orange. They hatch in about two weeks, and the minute, elliptical, yellowish larvae enter the base of the buds where they remain until the following winter.

These larvae cause the needles to become stunted and deformed, and as three-fourths or more of the needles in many fascicles may be thus affected the result is almost the same as a partial defoliation of the trees. Repeated attacks greatly weaken the trees, making them much more susceptible to the attacks of wood-boring beetles and other insects. We have often noticed that a destructive outbreak of bark beetles may follow, within one or two years, a serious infestation of the midges.

Although the Monterey pine, *Pinus radiata*, suffers most severely from the attacks of this midge, other species such as *P. tuberculata*, *P. muricata*, *P. sabiniana*, *P. coulteri*, and *P. sylvestris* are also attacked.

Fortunately there are a number of natural enemies which help to control this pest. A small predaceous mite, *Pediculoides ventricosus* (New.) feeds on the eggs, larvae, and pupae. A small, black, hymenopterous parasite, *Polygnotus diplosidis* Ash., an enemy of the closely related eastern midge, also attacks the western species. Larvae and adults of certain lady beetles and other predaceous insects likewise do their part by destroying many larvae and pupae. The ruby-crowned kinglets eat many of the female midges as they are on the buds ovipositing.

FIG. 225.—Effects of a bad infestation of Monterey pine midge, *Thecodiplosis piniradiatae* (Snow and Mills).

The pine needle gall fly, *Cecidomyia pinirigidae* Pack., is much like the species just described in appearance, habits, and its effect on the infested needles. It occurs on the needles of *Pinus rigida* in the eastern United States but rarely becomes abundant enough to be of any importance. It is probably held in check by its chalcid parasite.

Kidney-shaped enlargements 7 mm. long and 4 mm. in diameter at the base of the needles of *P. edulis* are caused by *Thecodiplosis cockerelli* Felt. The same species may cause a globose swelling 1 to 3 cm. long and 4 mm. in diameter on the leaves of the same host.

Elongate, cylindrical, or fusiform green or purplish-red swellings at the base of the needles of *P. edulis* and *P. monophylla* are caused by *Cecidomyia* sp.

Janetiella coloradensis Felt causes globose swellings at the base of the needles of *P. virginiana*.

The pine bud gall, *Contarinia coloradensis* Felt, causes apical budlike swellings on twigs of *P. scopulorum*. A similar gall on the same host is caused by *Dicrodiplosis gillettei* Felt.

A subglobose terminal swelling on the tips of the new growth of *P. edulis* is caused by *Cecidomyia* sp. "This kills the apical needles, though the lower ones continue to develop and in old deformities may produce a ring of short, stout, upstanding needles surrounding a central dead area" (Felt, 1917).

The gouty pitch midge, *Retinodiplosis inopis* O. S., causes distinct swellings on twigs of *Pinus rigida.* The infestation is accompanied by more or less exudation of pitch, and the resinous cocoons of the pupae make conspicuous objects on the needles.

The same or a very closely related species attacks the twigs and leaders of ponderosa pine causing a whorl in the annual rings of growth. This injury becomes incorporated in the wood causing a

FIG. 226. "Bird's-eye" in ponderosa pine caused by *Retinodiplosis* sp. (*U.S. Dept. Agr. Bur. Entomol. Plant Quar. Photo by Miller.*)

defect known as "bird's-eye pine" fairly common in sections of California and Oregon.

Still another midge, belonging to the same genus, causes irregular, subhemispherical or oval eccentric swellings on the twigs of *Pinus taeda.*

The pitch midge, *R. resinicola* O. S., infests several species of pines along the Atlantic Coast. The larvae are remarkable because of their living in the pitch which exudes from wounds in the bark. They derive their nourishment from the plant tissue at the edges of the wounds. Except for the fact that the larvae keep the wounds from healing as soon as they otherwise would heal, they do no especial harm unless the tree suffers from the loss of pitch. Pupation occurs within the mass of pitch, and just before the adult issues the pupae come to the surface of the mass. The delicate white pupal skins protruding from the resinous mass are often quite conspicuous. Three or more parasites keep this insect from becoming overabundant.

The western pitch midge, *R. resinicoloides* Williams, occurs in the Monterey pine in the West. Its habits are very much like those of the species just described.

A western species quite similar to *R. resinicoloides* causes peculiar defects in the annual rings of ponderosa pine. These defects in the lumber are the cause of the so-called "bird's-eye pine."

The southern pitch midge, *R. palustris* Felt, is found in the pitch of *Pinus palustris*.

The banded pitch midge, *R. albitarsis* Felt, has been reared from the pitchy exudation on branches of *Pinus strobus* which were infested with the pitch moth, *Parharmonia pini* Kell.

On Firs, Spruces, and Hemlocks

The balsam gall midge, *Cecidomyia balsamicola* Linter., is widely distributed throughout the East. It produces oval enlargements near the base of balsam needles, sometimes causing many of them to drop.

The spruce gall midge, *Phytophaga tsugae* Felt, causes bud galls and swellings at the base of the leaves on fir, spruce, and hemlock.

The spruce bud midge, *Rhabdophaga swainei* Felt, causes apical bud galls.

The spruce seed midge, *Dasyneura canadensis* Felt, has been reared from seeds of white spruce, *Picea canadensis*. It destroys the seeds without causing a deformity of seeds or cones.

On Southern Cypress (Taxodium)

The cypress leaf gall, *Itonida taxodii* Felt, appears as conical globular or elongate deformations of the leaves of cypress.

The cypress twig gall, *Thecodiplosis ananassi* (Riley), occurs on the smaller stems or twigs of *Taxodium distichum*. The galls are roughened, rounded or elongate, resembling a miniature pineapple.

The cypress flower gall, *I. anthici* Felt, is readily recognized because of its flower-like appearance. The galls are about 3.0 mm. in length, somewhat bell-shaped, with the margins more or less expanded. They are sometimes very abundant on the cypress, *T. distichum*, and their pinkish-white colors make them very conspicuous.

The cypress seed midge, *Retinodiplosis taxodii* Felt, causes irregular, thick-walled, somewhat spongy galls, which are really modified seeds, in cones of *T. distichum*.

On Other Conifers

The white cedar bud gall, caused by *Cecidomyia* sp. on *Chamaecyparis*, is larger than the normal bud, densely imbricate, and contains a narrow cell inhabited by a reddish larva.

Janetiella siskiyou Felt has been reared from the seeds of *C. lawsoniana*.

The arborvitae bud gall is caused by *Rhopalomyia* sp.

The juniper berry midge, *Walshomyia juniperina* Felt, has been reared from slightly enlarged fruits of *Juniperus californicus* and *J. monosperma* and also from conical, purplish, apical bud galls.

The juniper cone gall, caused by *Oligotrophus betheli* Felt, is a reddish, apical, conical gall on *J. utahensis*.

Allomyia juniperi Felt causes prickly, burrlike bud galls on *Juniperus*.

A greenish, apical, rosette gall about 1.5 cm. in length on *Juniperus* is caused by *Cecidomyia* sp.

The mountain cedar midge, *Walshomyia texana* Felt, causes bud galls on *J. mexicana*.

Phytophaga piceae Felt attacks the base of needles or small twigs of *Picea canadensis*, causing the twigs to swell to twice normal size.

On Deciduous Trees

Many of our deciduous trees and shrubs are also attacked by gall midges, and characteristic galls are formed on them. More than forty species have been recorded from the willows, twenty from the oaks, and about as many from the hickory. Most of these are of but little or no importance or interest from the viewpoint of forestry, so no attempt will be made even to list all of them here. A few, however, should be mentioned briefly.

The catalpa midge, *Itonida catalpae* Comst., is often a common and important pest on catalpa. The adult measures about 1.5 mm. in length, the legs are long, and the body is light yellow in color, the wings dusky. The eggs are minute, elongate, whitish, and when deposited on the foliage are found in masses of eighty or more.

The larva when mature is nearly 3 mm. in length and varies in color from pale whitish to orange. It possesses the ability to spring into the air to a height of several inches, the feat being performed by bringing both ends of the body together in bow fashion and suddenly straightening out.

The stunted growing tips of catalpa; the distorted leaves; the brown, eyelike spots or larger brown, deadened areas on the leaves; and the distorted, misshapen seed pods all are effects of the activities of this insect.

The injury to the foliage may take the form of circular feeding punctures about 6 mm. in diameter, or in the event of a destructive attack the entire leaf may wilt, later becoming brown and crumpled.

Frequently the trees may shed a considerable part of their foliage as a result of early summer outbreaks.

When the larvae gain access to the pods considerable distortion results, and, if abundant, the greater part of the seed may be destroyed.

The most serious aspect of the injury by the catalpa midge consists in the stunting and dwarfing of the trees as a result of the constant killing back of the terminal bud. When grown for posts or poles it is important that the terminal shoots and particularly the central one remain healthy and vigorous. Repeated injury to the terminal shoot causes excessive branching, and the outcome is a dwarfed, bushy growth instead of the straight, upright tree.

No satisfactory control measure is known for this species. Cultivated groves are less seriously attacked than uncultivated ones; hence it is advisable that cultivation be practiced until the trees are well started.

The linden twig gall midge, *Cecidomyia citrina* O.S., sometimes seriously stunts the growth of lindens by destroying the buds and reducing the vitality of the twigs by deforming them.

The tulip gall fly, *Thecodiplosis liriodendri* (O.S.), produces characteristic blisters on the leaves of the tulip tree and is often abundant enough to do considerable damage in the South.

The pine-cone willow gall is one of the most common of the galls made by members of this family. The presence of the larva of the gnat *Rhabdophaga strobiloides* (Walsh) in the tip of the twigs causes the conspicuous, pine-cone-shaped galls so often seen on some of the willows in the East. *R. racemi* Felt and *R. brassicoides* (Walsh) form somewhat similar galls on willows in the West.

BENEFICIAL MIDGES

The larvae of some of the midges are of considerable importance as predaceous enemies of mites, aphids, scale insects, and eggs; and a few are even parasitic. One of these, *Mycodiplosis acarivora* Felt, preys almost exclusively on several of our common mites. The larva of *Arthrocnodax occidentalis* Felt is an important enemy of mites and insect eggs in the West. *Aphidoletes meridionalis* Felt is listed as an important enemy of many aphids. The larvae of *Itonida hopkinsi* Felt have been taken from the mines of bark beetles in yellow pine, but they are not common and are probably of little economic importance.

THE SYRPHUS FLIES

The syrphus flies, family Syrphidae, range from quite small to medium size. They may be unicolorous, shining black, or greenish,

but more often they are dark with bands of yellow. Many resemble bees or bumblebees or wasps. The family is a large one, and most species are beneficial, the larvae feeding on aphids and other small, soft-bodied insects.

Several species of the genus *Chilosia* spend their larval life in the cambium of living trees, and their work results in a peculiar defect, known in the lumber industry as "black check."

The hemlock bark maggot, *Chilosia alaskensis* Hunter.—The adult is a small, black fly 10 mm. in length with a wing spread of less than 18 mm. and densely covered by black hairs.

The larvae belong to the rattail group. They are whitish maggots with a small head almost buried in the front end of the body, which is plump, subcylindrical, and covered with microscopic hairs or spines. There are fleshy appendages or false feet on most segments. The body terminates in a whiplike tail about as long as the body proper. The tail serves as a breathing tube and may be lengthened or shortened at will. The length of a full-grown larva is 15 to 20 mm.

The pupa forms in the last larval skin; the tail is bent over the back; the body becomes compact and appears to shorten. The puparium is 7 to 8 mm. in length.

Eggs are deposited in wounds caused by other insects, such as scolytids, and the larvae are found in the flow of resin with the body near the sapwood and the tail extending out through the resin mass to the air. The larvae feed upon the soft, growing tissue of the cambium, enlarging the wound as it grows. The resin flow is constantly pushed out, forming a globular mass on the tree trunk. The larva continues its work for several years (3 to 5) keeping the wound open. In the spring that full development is attained, it migrates to the outer portion of the resin mass to pupate. The transformation from larva to pupa and pupa to adult takes place in the outer resin mass. The adults emerge in late April and early May.

The entrance to the chamber in which the maggot has lived may be only the tiny wound made by a bark beetle, or it may be larger, but it is never changed by the maggot. The latter has spent its time in the inner chamber and often enlarges it to an inch in diameter. As soon as the maggot leaves to pupate, the irritation ceases, the wound starts to heal over and in a few years is covered, but underneath is the resin-filled pocket which is the black check of western hemlock lumber.

This black check appears as a dark-brown or black, resinous scar above which the layers of wood are distorted. In quarter-sawed boards it appears as a long seam; timber badly affected is worthless for finishing, turning, staves, or similar use.

This fly was described from Alaska and occurs south along the Pacific Coast to southern Oregon, being especially injurious in the lower Columbia and Puget Sound regions.

No adequate control has been worked out for this insect. It is, however, found that where clear material is required it is safe to obtain trees growing at an elevation of over 1,800 ft., since the flies have not been found attacking trees at such altitudes.

Two hymenopterous parasites have been found to attack the maggot, one an ichneumon fly, *Syrphoctonus maculifrons* Cr., and the other a Chalcididae, *Eutelus flavipes* Walk. Both appear to be common and undoubtedly exert some influence in keeping the maggots in check.

The lowland fir bark maggot *Chilosia hoodiana* Bigot, is similar in size but brown in color and works in the cambium of *Abies grandis* and *A. concolor*.

A very similar species works under the bark of Douglas fir, and damage to alpine fir and yellow pine have been reported, but the insects responsible have not been identified. Cole and Lovett (1921) list twenty-one species belonging to the genus *Chilosia* as occurring in Oregon; and some, aside from the two above, are probably bark maggots.

Xylota subfasciata Loew has been reared from decaying heartwood of Douglas fir. Whether the larvae are scavengers or predators is not known. Many other species of this genus are found in wood.

The family Syrphidae furnishes many very beneficial insects; in fact, many writers consider syrphid larvae as the most important factor in aphid control. *Syrphus americanus* Weid. probably is by far the most valuable species if the whole country is considered, since it is very abundant and has a wide distribution. Davidson considers *Lasiophthicus pyrastri* (L.) the most important species in California. In Oregon *Syrphus opinator* O.S. ranks first, with *S. americanus* Weid. second in importance.

Aphidiophagus syrphids deposit their eggs in aphid colonies, and 5 to 15 days elapse before hatching. The larvae feed for from 8 to 27 days and then require 5 to 24 days for pupation, the variations depending upon the species. Feeding experiments show that each maggot consumes 17 to 47 aphids a day or 265 to 530 individuals during development. In feeding, the aphid is grasped by the maggot, the mouth parts are fixed upon the body, the wall punctured, and the contents extracted.

Species of the genus *Medeterus*, family Dolichopodidae, are important associates of forest insects. Some of the larvae found under bark

are predaceous on other insect larvae. *M. aldrichii* Wheeler is a valuable predator of bark beetles in Western forests.

Lonchaea corticis Taylor, family Lonchaeidae, is a steel-blue fly about 4 mm. long with an oval elongate or almost round abdomen. Taylor reports it as one of the most important parasites of *Pissodes strobi* Peck in the East. *L. polita* Say has been taken from the burrows of *Ips radiatae* Hopk. in the West. *L. viridana* Meig. is found breeding under the bark and in cones of western forest trees. Under certain conditions it may be predaceous.

Oscinis sulphurhalterata Endl., family Oscinidae, breeds in the cones of *Abies grandis* in the West. *Siphonella* (*Madiza*) *conicola* (Green) has been reared from cones of *A. concolor* at Ashland, Ore.

Sarcophaga sarracenioides Ald., family Sarcophagidae, has been bred from some of the large wood-boring beetles such as *Prionus californicus* Mots and *Ergates speculatus* Lec. Eight flies emerged from one specimen of the latter beetle. *S. kellyi* Ald. has been bred from various cerambycid larvae.

Xanthophyte labis Coq., family Dexiidae, has been bred from the Douglas fir pitch moth.

The larvae of the genus *Ctenophora* and other genera of the family Tipulidae are often found in dead or decaying logs. Species of the genera *Tipula* and *Nephrotoma* have been reported as destroying seedling fir and larch and as injuring the young of other coniferous and deciduous trees (Alexander, 1920).

The robust robber flies, family Asilidae, are very commonly seen in the forests. They are important predators.

LEAF MINERS AND CAMBIUM MINERS

The flies of the family Agromyzidae are mostly very minute. There are about 100 known species in the United States. The larvae show a diversity of habit: Some are gall makers, others are leaf miners; three species mine the cambium of trees, causing pith-ray flecks; and lastly a few forms are predaceous, the larvae feeding mainly on aphids and scales.

Among the leaf miners only two species mine the leaves of forest trees. *Agromyza ulmi* Frost. mines the leaves of American elm, and an unnamed species works in the leaves of poplar.

A. tiliae Coud. forms galls on the twigs of linden trees.

A tiny, dark-blue species of this family was introduced into California years ago to prey upon scale insects; *Cryptochaetum iceryae* Will. proved very beneficial and is the only parasitic species of the family in the United States. It preys upon the cottony cushion scale.

A number of species are predaceous; *Leucopis piniperda* Mal. and *L. orbitalis* Mal. prey upon aphids which occur on pines.

The cambium miners include the following:

Birch cambium miner, *Agromyza pruinosa* Coq.—The adult is 3 (male) to 4 mm. (female) in length, of a grayish color with indistinct orange markings.

Eggs are deposited high up on the trunk of perfectly healthy trees, and the very minute larva works down in the cambium toward the roots.

The full-grown larva is 18 mm. long and only about 1 mm. in diameter. The head is fitted with a black, chitinized hooklet by which it mines through the cambium.

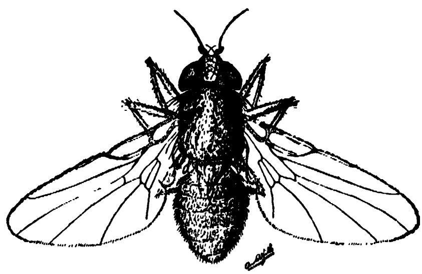

FIG. 227.—Adult of birch cambium miner, *Agromyza pruinosa* Coq. Greatly enlarged.

The mine at first is fine, almost hairlike, and gradually increases in size. The base of the tree is reached about the time that the maggot is full-grown, and it leaves the tree to pupate in the soil. The pupa is cylindrical, 4 to 5 mm. long by 2 mm. wide.

Adults appear in May to deposit eggs, and a year is required for the life cycle.

The damage is caused by the mines which traverse the cambium and later heal over. The tree may be attacked at intervals throughout its life. No external damage is noted, but when the birch is cut a cross section will show numerous black specks, and the longitudinal section will show streaks of varying length. These are known as pith-ray flecks.

The host is birch, *Betula nigra,* in the middle Atlantic states and as far west as Colorado.

Agromyza aceris Green, a small dark fly, is very similar to the last species; length 4 to 4.5 mm.

The larvae are opaque white, cylindrical, from 15 to 17 mm. in length, and about 1 mm. in diameter. They mine in the cambium of red maple, *Acer rubrum.*

The larvae reach maturity in July and pupate by mid-August, remaining in the soil until the following late April, when the adults emerge. They are common in the Atlantic states. Work similar to the above occurs in *Quercus, Salix, Populus, Alnus,* and other deciduous trees and is doubtless caused by closely related species. At the present time little is known of the food habits of a great number of

these Diptera, and much of the injury has not yet been traced to any particular species of insect.

In the West many species of coniferous trees show damage similar to pith-ray flecks. This has been considered as the work of small Diptera belonging to the Agromyzidae or Cecidomyiidae, but as yet no careful work has been done to identify the various species responsible for the injury.

Under grading rules these defects may result in lumber's being thrown into lower classes, but they do not affect the strength of the material, and, where abundant, they might be capitalized and the material used for finish where it should command a premium.

ROOT MAGGOTS

The members of the family Anthomyiidae look somewhat like the common houseflies, but they are smaller, and the abdomen is usually not so broad as in the houseflies.

The larvae of many species live in decaying vegetable matter but may bore into the roots or stems or leaves of living plants. The cabbage root maggots and onion maggots are common examples.

Some species have been found to be very destructive to the seeds of coniferous trees planted in experimental plots by the Division of Forestry at the University of California.

THE TACHINA FLIES

In size and general appearance many of the tachina flies, family Tachinidae, resemble somewhat the common housefly. The body is, however, usually more robust and furnished with heavy bristles or hairs. Many are much smaller, less than half as large; others are two or three times as large as the housefly. This is a very large family of great economic importance, as the larvae are parasitic, chiefly within caterpillars, but many other insects are attacked as well.

The eggs of many species are deposited directly on the host, and the larvae make their way into the body cavity where they live until ready to pupate. During the last few hours of their larval life they feed so greedily on the tissues of their host that they destroy it, frequently, but not always, before it pupates. Having completed their growth, the parasites usually pupate in the body of their host or in the ground.

Some tachina flies are ovoviviparous and deposit their living larvae in the body of their hosts. Others lay their eggs on the plants on which the hosts are feeding or over which they pass.

The tachina flies are such important factors in the control of many of our insect pests that many species have been introduced

into this country to help control such serious pests as the gypsy moth, the browntail moth and many others.

One of the most important insects introduced into the United States to help control the gypsy moth is the tachinid parasite *Compsilura concinnata* Meig. It passes the winter as an immature maggot in the hibernating pupa of its host. There may be three or four generations each year. Not only is this parasite one of the principal checks on the increase of the gypsy moth, but it is an important enemy of the browntail moth and several native insects. It has brought the white-marked tussock moth under control in the New England states and has had a marked influence in reducing the numbers of other pests such as the promethia moth, the fall webworm, the cabbage worm, and the army worms.

Sturmia scutellata Rob. Desv. is another tachinid that has been successfully introduced to control the gypsy moth, but it is restricted to this one host.

Admontia (*Hypertecteinia*) *retiniae* Coq. has been bred from the larvae of certain tip moths (*Eucosmidae*) infesting conifers.

Uramyia halisidotae (Ths.) (*U. acuminata* Bigot.) is about the size of a large housefly, quite bristly, and is an exceedingly effective parasite of the fir tussock moth. In a number of cases, colonies of the caterpillars have been brought to the laboratory, placed in cages, and 95 per cent were found to be parasitized. *Ernestia* (*Panzeria*) *anipelus* Walk. has been reared from the spotted fall webworm, *Hyphantria textor* Harris, in Oregon. *Zenilla* (*Exorista*) *vulgaris* (Fallen) occurs throughout the United States and doubtless attacks forest Lepidoptera, as it has been reared from the spruce budworm. *Z. futilis* (O.S.) has been reared from *Malacosoma disstria* Hbn. and other caterpillars. *Phorocera claripennis*, Macq. is a widely distributed species, common in the West; it attacks various caterpillars. *Frontina frenchii* Will. occurs in the West; it parasitizes *Malacosoma*. *Exorista larvarum* L. (*Tachina mella* Walk.) is very similar to the last. *Tachinomyia* (*Tachina*) *robusta* Ths. is a common Oregon species, reared from *Malacosoma*.

Blepharipeza adusta Loew is a larval parasite of the Pandora moth in southern Oregon and of *M. disstria* Hbn. in various parts of the West. *Madremyia* (*Phorocera*) *saundersi* (Will.) is a widely distributed species, attacking various caterpillars. Among other species it attacks the oak looper, *Ellopia somniaria* Hulst.

WALKING STICKS, GRASSHOPPERS, AND CRICKETS

The insects belonging to the order Orthoptera have the forewings leathery or parchment-like and the hind wings membranous and

folded in plaits like a fan. Many members of this order have rudimentary wings, or the wings may be wanting. The mouth parts are fitted for biting and chewing.

While this order contains many of our most common and some of our very destructive insects, only a few of these are of importance as enemies of forest or shade trees.

FIG. 228.—The northern walking-stick, *Diapheromera femorata* Say. About natural size. (*Kellogg's American Insects.*)

The northern walking-stick, *Diapheromera femorata* Say, is the most common and abundant species of a group of long, slender, sticklike insects. They feed on the leaves of oak, locust, hickory, wild cherry, and, to a lesser extent, other deciduous trees. Only rarely do they occur in destructive numbers. In the more tropical parts of the world, as in Queensland, Australia, they often destroy the foliage of the forest over great areas. Arsenical sprays may be used if control measures seem advisable.

Grasshoppers are often very destructive in fields and gardens, and when they are particularly abundant they may defoliate the trees and shrubs. They are seldom of any importance in the forests, except in mountain meadows, but in the Nebraska National Forest they have destroyed many planted pines. When they are feeding on shade or ornamental trees they may do considerable damage.

The katydids are also leaf feeders but seldom become numerous enough to do any appreciable damage.

The tree crickets may sometimes do some damage, particularly to young trees, on account of their habits of laying their eggs in punctures which they make in the bark or cambium of trees and shrubs. These punctures may kill small twigs or so weaken them that they are easily broken by the wind.

The snowy tree cricket, *Oecanthus niveus* (DeGeer.), a whitish or pale-green form, is one of the most common and widely distributed of these.

The black-horned tree cricket, *O. nigricornis* Walk., characterized by the very dark antennae, is almost or quite as common in some localities.

The pine-tree cricket, *O. pini* Beut., is reported only from pine trees, usually on the higher branches. Cutting and burning twigs infested with eggs will help to prevent possible damage by later generations.

FIG. 229.—The snowy tree cricket, *Oecanthus niveus* (De Geer.) × 1. Male. (*Kellogg's American Insects.*)

The mole crickets frequently do much damage to the roots of young trees.

The northern mole cricket, *Gryllotalpa hexadactyla* Perty, is the most common of these. The introduced European mole cricket, *Gryllotalpa gryllotalpa* L., has been reported as destructive to young forest trees. On account of the subterranean feeding habits of these insects it is difficult to control them. Poisoned baits, as used for cutworms or grasshoppers, give some relief.

A few of the true bugs, order Hemiptera, such as the box-elder bugs, *Leptocoris trivittatus* Say, family Corizidae, and others may attack some shade trees, but control measures are rarely necessary. Some of the lace bugs, genus *Corythucha*, family Tingidae; and the leaf bugs, family Miridae, may do much damage to sycamore, ash, willow, hawthorn, California Christmas berry, and other trees and shrubs. They are usually most abundant on the underside of the leaves.

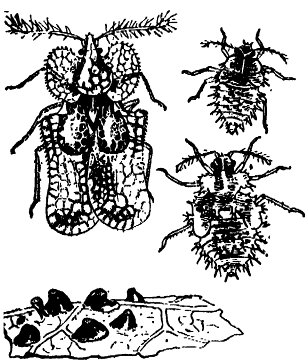

FIG. 230.—The California Christmas berry lace bug, *Corythucha incurvata* Uhler. × 8. Upper left, adult; right, a young and an older nymph; below, cone-shaped mass covering the eggs. (*Kellogg's American Insects.*)

The oak lace bug, *C. arcuata* Say, was reported as doing severe damage to oaks in Minnesota in 1929. Any of the oil emulsions adapted for summer spraying may be used when control measures seem advisable.

Many of the common stinkbugs, family Pentatomidae, live on plant juices, but some feed on other insects.

The assassin bugs, family Reduviidae, are important predators.

The dull-brown or black flat bugs, family Aradidae, are often found under the bark of dead trees where they are supposed to feed on the juice of the decaying wood or on fungi, the spores of which they may carry to other, possibly healthy, trees.

THE MITES

The mites and ticks, class Arachnida, do not belong to the same class as the insects, class Insecta, but most people look on them as kinds of insects, and the entomologist is usually called upon to give information in regard to them. The ticks are all parasitic on various animals; none attacks plants, so they will not be discussed here.

The mites constitute a large and important group of minute creatures almost as varied in their habits as they are in their appearance and structure. Many are parasitic, many different kinds of hosts being attacked. The itch mites of man and of domestic animals; various varieties of *Sarcoptes scabiei* DeGeer.; and the chigger mites, *Trombicula irritans* Riley, are examples of these. Many kinds of mites are found clinging to insects. Some of these are parasitic; others are simply using the insects as a means of transportation.

One of the most important of the parasitic mites is the ventricose mite, *Pediculoides ventricosus* Newport, which is parasitic on many insects and, under certain conditions, it may attack man also. As the eggs begin to develop in the body of the female the abdomen becomes greatly swollen. The head and thorax appear as small projections on this spherical mass. The young hatch within the body of the mother and begin attacking their hosts soon after they are born. As they feed on so many different kinds of insects they may destroy many beneficial as well as harmful insects.

Another group of mites are those that live wholly on the stems or leaves of plants, sucking the juices and thus seriously injuring their hosts. The term "red spiders" is applied to a number of these. It is difficult to determine the species in many cases, and even the systematists who are working with this group are not agreed as to proper names for some of the species.

The common red spider, *Tetranychus telarius* (L.), one of the most abundant of these, is very destructive in many sections. Although it is called a red spider or mite, its color varies from yellowish to orange or red or even greenish. The young are whitish yellow. The adults hibernate in the soil or in rubbish or in other protected places and begin feeding on the foliage of their host plants early in the spring. There are several generations during the summer months. This mite feeds on almost all kinds of wild and cultivated plants. It may, at times, be so abundant on pines and on some of our deciduous shade trees as to cause them to drop much of their foliage. This is particularly apt to occur during hot, dry weather. When control measures seem advisable sulphur dusts or sulphur sprays are usually recommended.

The two-spotted mite, *Tetranychus bimaculatus* Harvey, is another common and widely distributed member of this group. This species does not always have the characteristic red color, but during the time the mites are feeding they may be light or dark green with indefinite black spots on each side. They attack vegetable and truck crops, ornamental trees and shrubs, and many of our forest trees as well.

The spruce mite, *Paratetranychus ununguis* (Jacobi), is a very small, somewhat oval mite belonging to the web-spinning group.

It is reported by De Gryse as quite destructive to spruce in Canada; while Garman finds it very injurious to spruce, red pine, and cedars in Connecticut. Miller reports it harmful to pine in Ohio.

In Oregon it has been observed on Sitka spruce occasionally but was noted in July, 1930, at Miller Lake, Deschutes National Forest, in tremendous numbers killing quantities of lodgepole pine at about 6,000 ft. elevation.

The winter is spent as eggs, the young appearing in the spring. Development requires from 3 to 4 weeks, so there are several generations each year. The mites insert their beaks into the needles and extract the chlorophyll. When abundant they are quite noticeable owing to the browning of the needles and the presence of large quantities of fine webs.

The young are light grayish or green; when mature they are dark green to nearly black. Females are distinguished by a narrow, pale streak on the back and on the collar.

De Gryse recommends spraying infested trees with one part miscible oil to fifteen parts water early in the spring before the buds begin to burst. Later in the season many of the mites may be washed from the tree with a strong stream of water from a power spray pump. These remedies are, of course, applicable only in parks or small plantations.

The cedar mite, *Tenuipalpus erythreus* Ew., is a small red mite reported from cedar in Iowa and from arborvitae in Oregon.

The blister mites or gall mites are best known by the characteristic effects of their work on the leaves of their host plants. Some of them feed on the surface of the leaves, but most of them cause a felty mass of hairs or conspicuous galls on the undersides of the leaves. The mites are so small that they can scarcely be seen without the use of a lens. The bodies are elongated, and the abdomen is usually finely striated. In the full-grown mites there are two pairs of legs close to the anterior end of the body.

The walnut blister mite, *Eriophyes tristriatus erineus* (Nalepa), works on the underside of walnut leaves, producing a concave area which is

filled with fine, soft hairs among which the mites live and lay their eggs. They are usually of no economic importance.

The linden gall mite, *E. abnormis* (Gar.), causes conspicuous bright-red cone-shaped galls on the upper surface of linden and basswood trees.

The pine-needle mite, *E. pini* (Nalepa), lives under the bracts at the base of the needles on Monterey and Torrey pines. Sometimes the mites are so abundant that they cause many of the needles to fall prematurely.

The cottonwood mite, *E. populi* Nalepa, attacks the cottonwood and poplars, causing knotlike enlargements on the twigs and small limbs.

The juniper mite, *E. ramosus* Hodg., is a long, narrow, pinkish or red mite which deforms the fruits of *Juniperus pachyphaea* in Arizona.

The western cedar mite, *E. thujae* Gar., causes a yellowish discoloration of the terminal growth of *Thuja occidentalis.* It is widely distributed and may cause the death of young trees.

The maple erinose mite, *E. ryderi* Banks, causes thick brownish or yellowish, hairlike growths on the underside of maple leaves.

The willow gall mite, *E. salicicola* (Gar.), is a short, stout-bodied mite which causes many small galls on the upper and lower surfaces of willow leaves.

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CHAPTER XII

TERMITES OR WHITE ANTS

Termites or "white ants," order Isoptera, form a small group of insects very destructive to wood and wood products. Their principal food is cellulose from either dead woody material or living vegetation, although they are able to feed on almost any organic material. They are therefore beneficial to the forest as scavengers of dead and decaying trees, logs, and stumps but are also decidedly harmful when they transfer their activities to finished wood or the cellulose products of wood. In the United States they are particularly destructive to fence posts, telephone poles, grape stakes, buildings, and other woody objects that come in contact with the ground. On the Pacific Coast and in the southern states certain species are also very destructive to dry timbers, building, flooring, and other materials which are not in contact with the earth. They are also known to destroy furniture, books, and other organic matter which is in contact with infested wood. They never live exposed to the light, and so their work is often not suspected until the interior of the object attacked has been completely eaten out and the outer shell crumbles away under the slightest pressure.

Termites are small, flat, soft-bodied insects with biting mouth parts; with or without eyes; and usually pale grayish, light yellow-brown, or black in color. They have gradual metamorphosis, developing from eggs through nymphal forms to a number of specialized castes - workers, soldiers, or sexual adults. There is no true pupal stage, although there may be a quiescent or resting stage during molting. Most of the castes are wingless, but the migrating sexual forms or alates, which are usually dark brown or black, develop two pairs of similar long, narrow wings, which are folded flat over the back when at rest. When these adults establish a new colony the wings are broken off, and only the stubs are left.

Termites are social creatures and, like the true ants, social bees, and social wasps, live in small or large, well-organized communities made up of a number of specialized castes, each having its special work to do for the good of the colony. However, they have a greater number of castes than these other social insects, including two or three castes whose function is reproduction.

The workers are wingless individuals with soft bodies and large, unchitinized heads. Since they always live within the burrows and are never exposed to the light, they are pale, dirty-white yellowish, or light brown in color and are usually blind. They do most of the work in the colony, their duties consisting of excavating and feeding and caring for the young. They represent both male and female forms in which the sexual characters have not been fully developed. In some genera, such as *Kalotermes* and *Cryptotermes*, this caste is absent, and the work is done by immature nymphs of the reproductive forms.

The soldiers are similar to the workers in color and in being blind and wingless but are somewhat larger and have the head chitinized

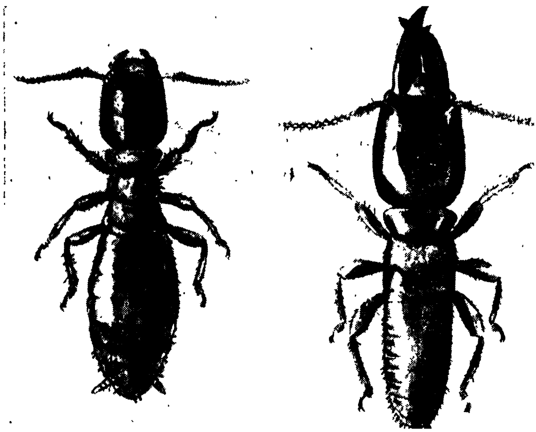

FIG. 231.—A worker and a soldier of *Zootermopsis angusticollis* (Hagen). Much enlarged. (*Jordan and Kellogg's Animal Life*.)

and the mandibles enormously developed. Like the workers, the soldiers represent males and females with undeveloped sexual organs, although in *Zootermopsis* fertile soldiers are found. Soldiers are produced by all the reproductive forms. Their evident duty is to protect the colony, but they do not appear to be very efficient in this respect.

In certain genera, as *Constrictotermes* and *Nasutitermes*, the soldiers are replaced by "nasuti" which, instead of the large mandibles, have the head prolonged into a beak or noselike process from which they exude a liquid which is used as a means of defense and also in making or repairing their earthlike tubes or passageways.

The normal or first reproductive caste.—The only termites ever found exposed to the sunlight and in flight are the sexually mature adults belonging to the normal or first reproductive caste. These

individuals are light to dark brown or black in color and have functional eyes and long, flat, narrow wings which extend beyond the end of the abdomen. They swarm and leave the old colony during the early summer and fly at dusk, often in great clouds, to find suitable locations for new colonies. A male and female upon finding a place to establish a new home lose their wings, retaining the stubs, carry on a courtship, mate, and become the true king and queen or royal pair of the new colony. The female then grows in size but in our native species does not become so large as to lose the power of locomotion, as do some species in the tropics. The king continues to cohabit with the queen, but since they are free to move about there is no centrally located royal cell. The queens have great fecundity and lay eggs at the rate of at least a dozen a day. These are white and kidney-shaped and from 1 to 1.5 mm. in length. They are usually laid in clusters along the tunnels and are tended by the young parent adults in the royal cells or removed by the workers and cared for by them in the outer galleries.

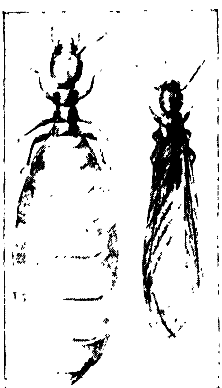

FIG. 232.—Reproductive castes of a termite, *Zootermopsis angusticollis* (Hagen). Queen with abdomen extended with eggs and a winged male. Much enlarged. (*Jordan and Kellogg's Animal Life.*)

The second reproductive caste.—The second reproductive caste are pale-gray or straw-colored individuals, with no functional eyes or wings and with short wing pads. They never leave the colony unless by subterranean tunnels and so, although capable of giving rise to new individuals within the colony, are incapable of establishing new ones. If the primary king and queen die, their place is taken by members of this second form or substitute kings and queens. However, the second form breed true to type and are unable to reproduce the first form.

The third reproductive caste.—In some genera there is a third reproductive caste within the colony. These are similar to the second sexual forms except that they have no wing pads and hence resemble the workers. Like the second form they probably never leave the colony and always breed true to type.

NATURE OF WORK

In the tropics, where termites are most abundant, some species build their nests as huge mounds 10 ft. or more in height or as exposed globular nests on trees, stumps, or other objects. In the temperate zone they do not build these large exposed nests but work, for the

most part, underground or completely within some woody object. Species found in the United States have three general types of work:

1. Wood-inhabiting species which do not require contact with the ground. Some of these, such as *Zootermopsis*, live in moist wood and are, as a rule, not particularly injurious to works of man. Others, such as *Kalotermes*, live in very dry wood and are exceedingly destructive to buildings, telephone poles, and other woody structures in the southern part of California and the southern states.

2. Wood- and earth-inhabiting species which must have moisture and contact with the ground and extend their galleries from the ground into the wood. This group includes some very destructive species, particularly in the eastern states.

3. Purely earth-inhabiting species which live upon decaying organic matter in contact with the soil and hence, from the forestry and forest-products standpoint, are of no economic interest.

The wood-inhabiting termites have in their intestines a very remarkable assemblage of small plant and animal microorganisms including Protozoa, spirochaetes, and bacteria. Each species has been found to have its own particular group of microorganisms, which may be found in the intestines of every member of the colony. It is believed that these serve the purpose of helping to digest the cellulose taken in by the termites and make it available for use.

They also have a number of fungi associated with them. These grow upon the walls of their tunnels, upon the fecal pellets, and are found in the intestines of the termites, indicating that they form a common element in their diet. To what extent these fungi help in breaking down the wood and making it available for food has not been fully determined, but it is probable that some such relationship exists.

PREVENTION AND REMEDIAL MEASURES

The methods of prevention and control of termite damage will depend upon the species involved, the type of work, and the character of material infested.

In most cases it is much simpler and cheaper to prevent the attack of termites than to control them after the colonies have once become established. With living forest trees, about all that is necessary is to avoid wounds that lay the wood bare or injury by insects, disease, or fire.

To avoid the destruction of buildings and woodwork there are several precautions that should be taken. Whenever feasible, all wood that is to be exposed to termite attack, by either the dry-wood or the subterranean species, should be impregnated with coal-tar creosote applied under pressure, according to standard specifications. Zinc

chloride; sodium silicofluoride; mercuric chloride; chlorinated naphthalene are other approved chemical preservatives which have been proved toxic to termites. At least wood which is to come in contact with the ground should be so impregnated. Where the use of chemical preservatives is not economical or practical, termite-resistant woods such as the sound, seasoned heartwood of cedar, chestnut, southern cypress, juniper, black locust, redwood, or black walnut should be selected. In any case, untreated wood should be insulated from contact with the ground. Detailed building instructions advise using a foundation that will keep woodwork 18 in. or more aboveground, constructed of solid cement or brick and mortar coated with a 1-in. thickness of cement, having a metal shield or guard projecting 2 in. or more from the foundation and turned downward at an angle of 45 deg.

In the southern part of the United States, in California, and in the tropics, where dry-wood termites are plentiful, impregnating wood with preservatives according to standard specifications or the use of termite-resistant woods is about all that can be done to prevent attack of these species. Telephone poles should be impregnated for their entire length. If surfaces are well-covered with paint, a certain degree of protection is afforded.

After poles, buildings, or woodwork have become infested, remedial action is required. In so far as is practical, all badly damaged wood should be removed, burned, and replaced with termite-resistant material. If subterranean species are working in buildings, they can be killed by shutting off their connection with the ground or other sources of moisture. If in untreated poles or posts where ground contact is unavoidable, ground treatment with sodium arsenite and other chemicals may serve to halt the damage, but as yet no entirely satisfactory method of treatment under such conditions has been found.

Colonies of dry-wood termites can be successfully killed by injecting poison dusts into their tunnels. The Termite Investigations Committee in California have found that the best dusts for this purpose are Paris green, arsenical smelter dust, and finely ground sodium fluosilicate. These dusts when injected into the wood tunnels are more effective in killing the entire colony and much more easily applied than fumigation with hydrocyanic acid gas, carbon bisulphide, or orthodichlorobenzene which have frequently been recommended for this purpose. The use of these dusts has, however, been generally abandoned on account of the danger to human life.

In general, the control of termites is largely a matter of using termite-resistant wood, either the sound heartwood of certain resistant

species or woods impregnated with toxic chemicals; keeping wood covered with paint; or building according to standard specifications which will preclude chances of termite attack.

CLASSIFICATION

The termites found in America north of Mexico are divided into three families, the Kalotermitidae, the Rhinotermitidae, and the Termitidae.

Members of the family Kalotermitidae are entirely wood-inhabiting species which live above the ground and do not require connection with it to obtain their moisture supply. The family is characterized by having the clypeus not divided by a median line; fontanel absent in all castes; gula longer than broad; ocelli usually present, and radial sector of wing with one or more superior branches (rarely none); pronotum flat and usually broader than the head; and no worker caste. Four genera are found in this country, *Zootermopsis, Kalotermes, Paraneotermes,* and *Cryptotermes.*

Members of the family Rhinotermitidae are mostly earth-inhabiting or subterranean termites. They are characterized by having the fontanel present; anterior wing scale large; wings often reticulate and without hairs; and the pronotum of workers and soldiers flat, without anterior lobe. The family is represented in the United States by three genera, the very destructive genus *Reticulitermes* which is responsible for the major part of the termite damage in the world; the genus *Heterotermes,* also subterranean habit; and *Prorhinotermes* which are damp-wood termites.

The members of the family Termitidae in the United States are, for the most part, small species which require considerable moisture for their development and are all ground dwelling in habit. They either live entirely within the ground or extend their galleries from the ground into the woody material upon which they feed. The winged adults are characterized by having the clypeus divided by a median line; the fontanel present and more or less distinct; the gula as broad as long; pulvillus absent; cerci two or three segmented; and the radial sector of the wing without superior branches. This family is represented in the United States by three genera, *Nasutitermes, Anoplotermes,* and *Amitermes* all of which are ground dwelling in habit and hence of no particular importance to forest trees.

From the standpoint of their habitat and the type of work that termites do, the species are readily divided into two major groups, the wood-dwelling and the earth-dwelling types, and these can be further subdivided into smaller groups with characteristic habits. For instance, among the wood-dwelling species is one group that

inhabits damp wood and a second group known as dry-wood termites. Then, in the earth-dwelling division are those which are subterranean in habit but extend their galleries by means of covered runways into woody structures aboveground; and those which live entirely underground and feed upon wood in direct contact with it. For convenience the various genera will be discussed according to these typical habit groups.

The Damp-wood Termites

At the time of swarming, the damp-wood termites enter directly into the wood through decayed spots, cracks, holes, or where knots have been removed and then follow the grain of the wood with their burrows. They require considerable moisture for their development and hence are usually found attacking moist, decayed wood in contact with the ground, but once entered they are capable of extending their galleries into relatively sound and almost dry wood. In the forests they are for the most part beneficial in causing the rapid decay of stumps, snags, and other forest debris. They cause little damage to finished wood products except under special circumstances, as when wood is kept unnaturally moist.

FIG. 233.—Work of termite, *Zootermopsis angusticollis* (Hagen), in alder trunks.

Members of the genus *Zootermopsis* (*Termopsis*) are the most important representatives of damp-wood termites in the United States. These are large species which normally live in the moist, decaying woods of logs and stumps and show a decided preference for the wood of coniferous trees. There are usually four castes in the colony, the three reproductive castes and the soldiers. There are no true worker castes, but the work is done by nymphs of the third reproductive form, which are large, worker-like, grayish-brown individuals with no wing pads. The adults swarm at night and are relatively strong fliers. There are three species found in the United States, all in the states west of the Rocky Mountains.

Zootermopsis angusticollis (Hagen) is one of the largest found in this country. The adults are light grayish to yellowish in color and 15 to 19 mm. in length. The soldiers have dark, reddish-brown heads

with immense black mandibles. This species is most frequently found in the moist coastal regions of California, Oregon, Washington, and British Columbia where it lives in the stumps, snags, and logs of various forest trees and also in the fruit and shade trees and in wooden structures kept damp from various causes. While usually of little economic importance, it sometimes does considerable damage to bridge timbers, fence posts, telephone posts, railroad ties, and under the framing of houses. In the Pacific Northwest its work frequently becomes of economic importance.

Z. nevadensis (Hagen) is similar to the preceding except that the body and wings of the adults are darker brown. It also works commonly in coniferous woods and is distributed in the drier and higher areas from central California north into Oregon, Washington, and British Columbia and eastward through Nevada, Idaho, Utah, and Montana to the western slope of the Rocky Mountains.

Z. laticeps (Banks) is also similar to *angusticollis* except that the head and body have long, erect hairs. It is a rarer species of limited distribution in the mountainous regions of southern Arizona and New Mexico where it works in the moist wood of cottonwood, willow, and other local trees.

The desert damp-wood termite, *Paraneotermes simplicicornis* Banks, is distributed through the arid desert regions of southern California, Nevada, Arizona, New Mexico, Texas, and Mexico where it attacks mesquite, and various other desert shrubs and trees. It is a frequent cause of injury to untreated telephone poles and posts and recently has been reported attacking and killing young citrus trees.

Prorhinotermes simplex Hagen is the only representative of this genus found in the United States. It is a native of the West Indies but is also found in southern Florida working in the damp, dead logs of the mangrove swamps.

The Dry-wood Termites

The group of termites mostly belonging to the genus *Kalotermes* which directly attack relatively dry wood without necessarily having any contact with the ground are called the dry-wood termites. They are distributed through the tropics and subtropics, but a few important species range as far north as the southern states and central California. They are the most difficult group to combat, since they can enter wood directly through any knot, crack, or crevice and require only a minimum amount of moisture to continue their destructive work. Some of the most extensive damage to telephone poles in southern California has been caused by members of this group.

Members of the genus *Kalotermes* are medium-sized termites with ocelli and two- or three-segmented cerci. The colonies are often of large size and completely riddle the wood of dead trees, telephone poles, and other dry, woody objects. On entering the wood they form irregular, oval, longitudinal chambers which are connected by narrow passageways and do not follow the grain of the wood. Some fourteen species are now listed as found in the United States, of which four are of considerable economic importance.

The common dry-wood termite.—The most destructive American species of dry-wood termite is *Kalotermes minor* (Hagen) which is distributed chiefly along the warmer coastal region of California into Arizona and northern Mexico but has been found as far north as Tacoma, Wash. It normally attacks and lives in the sound, dry wood of stumps, dead branches, and broken portions of the native trees such as sycamore, oak, alder, Monterey cypress, redwood, California laurel, buckeye, willows, and other trees and woody shrubs. With the coming of civilization, it has expanded its activities to include fruit and ornamental trees, posts, telephone poles, and bridges. Less frequently buildings are attacked, particularly around the doors, window sills, in rafters, sheeting, and other points where dry, untreated wood is exposed. The alates are bluish black with fine, short hairs on the body and heads less than 2 mm. in width. They measure from 11 to 12 mm. to the tip of their dusky wings in which the median vein is not joined to the radius sector and lies midway between it and the cubitus. The soldiers have reddish-brown heads, black mandibles, and brown bodies shading to a dirty yellow. The nymphs are the most abundant form found in a mature colony. These are whitish in color and in the seventh instar have wing pads.

FIG. 234. Work of termites in an old Douglas fir sill taken from a building.

Swarming takes place from late September to Nov. 1, and flight occurs during the middle of the hottest, brightest days. The new alates seek out a place to start a new colony and, on finding a suitable place, alight and shed their wings. As soon as mating takes place a pair start excavating a tunnel into the wood and once below the surface enlarge the tunnel into a pear-shaped royal cell. Here are

laid the eggs from which soldiers and occasionally one or more secondary queens arise. As the colony grows, tunnels are excavated deeper into the wood. The main passage is usually parallel to the vertical axis of the tree or pole and somewhat oval in outline but more often quite irregular. Spring and summer wood are eaten without preference, but the tunnels are always so constructed as to leave at least a shell of outer wood to protect the galleries.

In a year's time a new colony is little more than started and consists only of the primary king, queen, and a few nymphs. By the end of the second year about 3 cc. of wood has been destroyed, and the colony has increased to include about a dozen nymphs and one soldier. The queen reaches her maximum egg-laying capacity about the time she is ten to twelve years old. It probably takes a little over a year for a nymph to progress from the egg stage to a full-grown alate. So it is evident that while the work of this species may be exceedingly destructive, it is at least a relatively slow process.

This dry-wood termite has been given particular attention in California during the past few years on account of its great destructiveness to telephone poles. In buildings its damage has not been so important as that caused by other species.

The southwestern dry-wood termite, *Kalotermes hubbardi* Banks, is a similar species 12 to 13 mm. in length, but is much lighter in color and has pale wings. It ranges from the Colorado River Valley in southeastern California where it breeds in the giant cacti, cottonwoods, and other native trees but apparently prefers wooden structures wherever these are available. Living as it does in the hot desert country, it is capable of withstanding surprisingly high temperatures and much drier conditions than its near relatives. Unlike *K. minor* the alates fly at night. Its economic importance is limited only by the scarcity of damageable wooden structures within its range.

Other western species of *Kalotermes* include *K. occidentis* Walker which is the largest of our native species (14 to 15 mm. in length), distributed through southern Arizona and southern California. *K. arizonensis* Snyder; *K. banksi* Snyder, and *K. lighti* Snyder, which are rare species found in Arizona; and *K. texanus* Banks which is occasionally found in Texas.

In the eastern states damage from dry-wood termites is comparatively slight except in a limited coastal zone along the Gulf of Mexico and the Atlantic Coast as far north as Washington, D. C.

Of these, *K. snyderi* Light (*K. marginipennis* Latreille) probably does the greatest amount of damage; it may be found attacking telegraph and telephone poles, fences, the woodwork of buildings,

and other wooden structures as well as dead trees, logs, and branches. It swarms at night during May and June and is distributed along the Gulf of Mexico, in Florida, and in South Carolina.

K. approximatus Snyder is the only dark-colored eastern species. It has been found only in the dead stumps of sweet-gum trees in northern Florida, in dead bald cypress in southern Virginia, and in New Orleans. It no doubt works in various woods and wooden structures.

Other eastern species of *Kalotermes* are comparatively rare in the United States and are found mostly in Florida which represents the northern extension of their range from Central America, Mexico, and the West Indies. These include *K. schwarzi* Banks which is common in southern Florida; *K. jouteli* Banks, found in southern Florida and the Keys; *K. castaneus* Burmeister, living in various parts of dead trees in southern Florida; *K. angustoculus* Snyder, similar to the last; and *K. nearcticus* Snyder, also found in Florida.

The powder-post termites.—The so-called "powder post" or "house termites" are small forms of the warm tropics which live in numerous little colonies in very dry wood, from which they exude very small, powder-like, fecal pellets. They attack house timbers, furniture, isolated boards, and are capable of living in small pieces not over quarter of an inch in thickness. This group is represented in the United States by the genus *Cryptotermes* of which two species are found in Florida. The head of the soldiers has a concave or truncated appearance.

Cryptotermes brevis Walker is the most destructive species of this group and in southern Florida is particularly harmful to buildings, books, furniture, and even clothing. *C. cavifrons* Banks is less abundant and also found in Florida where it attacks dead wood of red mangrove and other trees.

The Subterranean Termites

By far the larger number of termite genera are earth dwelling in habit and live either entirely within the ground feeding upon wood in or in direct contact with it; or those which dwell in the ground and extend their work to wooden structures aboveground by means of covered runways. The first group are relatively unimportant, but the second, the so-called "subterranean" termites, cause the major part of termite damage throughout the world.

The subterranean termites start their colonies in the ground or in moist, decaying wood in direct contact with it. Here the royal cell is established, eggs are laid, and the first feeding begins. After the colony has increased in numbers the zone of activity may be extended

by means of covered runways to wood above ground and not necessarily in contact with it. These runways are composed of earth particles, wood fragments, fecal matter, and possibly salivary excretions which serve to cement the particles together into a solid tunnel. No matter how far these tunnels may be extended to reach wood—and in some cases this may be for 50 ft. or more—contact always must be maintained with the ground in order to keep up the constant moisture supply. In the United States, termites of this group are represented by two genera, *Reticulitermes* and *Heterotermes*.

Species of the genus *Reticulitermes* are among the most destructive forms found in the North Temperate Zone. By means of their earth-walled tubes or passageways, they sometimes travel up into the third floor of wooden buildings. In constructing their mines they usually follow the grain of the wood and after a time completely honeycomb it, leaving only a thin outer shell to conceal their damage. Ten species of the genus are widely distributed throughout the United States but are especially destructive in the eastern, southern, and central states.

Of the six species of *Reticulitermes* found in the Eastern half of the United States *R. flavipes* Kollar is the most common and destructive one. Damage to telephone and telegraph poles; fence posts; wooden buildings; books, papers, and furniture in storage; and various other wood or cellulose materials including even crops, flowers, living trees, and shrubs is widespread and runs into millions of dollars annually. This damage is made possible by the termites' ability to extend their covered runways for long distances over foundations and thus reach wood not in contact with the ground. The winged adults are dark brown to black in color, 10 mm. in length to the tip of the wings. These leave the old colonies and swarm during April and May and again in the autumn. As many as four swarms may emerge from one old colony during a period of a month. A short flight is made, and then new pairs shed their wings and start incipient colonies in pieces of decayed wood on or in soil. Unlike the dry-wood termites, there is no permanent royal cell, but the king and queen usually find protection in the inner, harder wood. If the moisture supply is sufficient, these new colonies prosper and slowly increase in numbers from eggs laid by the reproductive forms. In time the colony may grow until it contains hundreds of thousands of individuals, composed of the various castes of which the workers and macropterous forms are the most abundant.

Other eastern species of *Reticulitermes* include *R. virginicus* Banks which is similar to *flavipes* but smaller in size and swarms about a month later; and *R. hageni* Banks which is also similar, but the alates

are a pale, yellowish brown in color. Both of these are of more restricted distribution and are confined to the southeastern states. *R. lucifugus* Rossi, a European species, is found in the vicinity of Forest Hills, Mass., where it is supposed to have been introduced from the Mediterranean. *R. arenincola* Goellner is restricted to the Chicago area where it is found in decaying wood of sandy places.

The western subterranean termite, *R. hesperus* Banks, the most destructive, is distributed along the Pacific Coast from British Columbia to southern California, extending eastward into Idaho and Nevada. It is primarily a woodland species, attacking all sorts of dead or decaying wood, from the sagebrush of the very desert edge to coniferous trees in open forests of the Transition Zone, but is largely replaced by *R. tibialis* in the hot valleys of California and the Great Basin. From these native hosts it has extended its operations to the woody products of civilization and is easily the most destructive enemy of untreated telegraph and telephone poles, fence posts, buildings, and the contents of poorly constructed storage vaults of any termite within its range. It also has been found attacking fruit trees, artichoke plants, potatoes, and a great variety of dying woody shrubs and plants. The tunnels usually start in decayed wood in or on the ground and then extend through the ground and by means of closed passageways as far aboveground to reach feeding areas as the termites are able to control the moisture supply. These tunnels have a characteristic irregularity of pattern which distinguishes the work of this termite.

The winged alates are dark brown to black, with darkened tibiae, and are from 8 to 9 mm. in length to the tips of the wings. Swarming occurs in the fall and again in the spring on the first clear day following a rain. After a short, weak flight the new alates shed their wings and seek a mate. After pairing they seem to be repelled by light and seek shelter under any woody object in contact with the ground. The loss of reproductive forms during flight is tremendous, but the few that are successful in finding a suitable place to start a new colony rapidly burrow in and form an irregular cell which they carefully clean and block up.

A colony develops slowly. A few eggs are laid at intervals of from 2 to 10 days until the first clutch of about ten eggs has been laid, and this process continues with short, quiescent periods as long as this queen lives, which may be for five years or more. On hatching, the young termites feed during the first instar on intestinal excretions apparently as a means of acquiring the necessary intestinal Protozoa which appear in the second instar. From six to seven instars are passed through before the termites reach the stage of full-grown workers, and this takes from eight months to a year;

a colony has to be from three to four years old and of a large size before the winged reproductives are again produced. The workers live from three to five years, and with the more or less continuous egg laying the colony gradually increases in size. But even so, it is difficult to understand how colonies numbering hundreds of thousands of individuals can be produced in structures only two or three years old except through the merging of several contiguous colonies.

In recent years this species has been the subject of detailed investigations by the Termite Investigations Committee of California because of its serious depredations to dwellings, commercial buildings, and the contents of basement storage and concrete bank vaults. While this damage runs into thousands of dollars, it is rare to find a building so seriously weakened as to threaten collapse, and only one actual case of collapse has been reported.

Five other species of *Reticulitermes* are found in the western states, some of them of economic importance.

The barren-lands subterranean termite, *R. tibialis* Banks is the species commonly found in the more arid regions of the central prairie states, in the Great Basin, the warm central valleys of California, and south into southern California. The winged alates are almost wholly shining black in color, with blackened tibiae, broad heads, and pronotum and are from 9.5 to 10 mm. in length. They swarm in both spring and fall, and their habits are very similar to those of *R. hesperus*, but the total damage caused is less because they inhabit a more thinly populated region.

R. humilis Banks is a smaller and somewhat lighter colored species than *tibialis*, infesting the dead wood of various trees and woody plants in Arizona, New Mexico, and Mexico. *R. tumiceps* Banks is a rare Arizona species similar to *tibialis* but with the head in the soldier caste plainly broader behind. *R. claripennis* Banks is frequently found in Mexico and north into Texas, Arizona, New Mexico, Oklahoma, and Kansas.

The genus *Heterotermes* (*Leucotermes*), also of subterranean habit, is represented by several species of economic importance in tropical and subtropical America.

The desert subterranean termite, *H. aureus* Snyder, is the only species that ranges north into southwestern United States. It is found in the Colorado and Gila deserts living in the dead stalks of ocotillo, giant cactus, and other desert plants. It is similar in habit to *Reticulitermes* except that the covered tubes are smaller and more circular in outline and the fecal spottings and frass are light yellow in color. It is very persistent in building up its tubes over impervious foundations to reach susceptible wood and is capable of working in

oak, ironwood, and other very hard woods. If it were not for the fact that its distribution is limited to sparsely settled regions, it might easily prove one of our most destructive termites and has already shown itself to be a serious menace to posts, poles, and buildings in certain parts of Arizona.

The Earth-dwelling Desert Termites

Members of the genus *Amitermes* are small to medium-sized termites which in the United States are largely confined to the desert and arid regions. The winged alates have ocelli, a very distinct fontanel, and an outer as well as two inner apical spines on the front tibia. The soldiers have mandibles with a marginal tooth and a diamond-shaped pronotum. They are earth dwelling in habit, either feeding on the surface of buried pieces of wood or constructing tubes of sand over wood objects aboveground within which they eat away the weathered portions. Some damage has been reported to grazing plants, posts, poles, and citrus trees, but from the forest standpoint they are of little or no importance.

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APPENDIX

THE MORE IMPORTANT CONIFEROUS TREES OF THE UNITED STATES AND SOME OF THEIR PRINCIPAL INSECT ENEMIES

Abies balsamea. Balsam Fir

Buprestis maculativentris
Cacoecia fumiferana
Dicerca tenebrosa
D. tuberculata
Ips borealis
Melanophila abies
M. fulvoguttata
Monochamus confusor
M. marmorata
Pityokteines sparsus
Scolytus piceae

Abies concolor and A. grandis. White and Grand Fir

Buprestis aurulenta
B. rusticorum
Cacoecia fumiferana
Chalcophora angulicollis
Criocephalus asperatus
C. productus
Dicerca tenebrosa
Ergates spiculatus
Gnathotrichus retusus
G. sulcatus
Megastigmus pinus
Melanophila drummondi
Melasis rufipennis
Monochamus scutellatus
Pityokteines elegans
Pityophthorus pseudotsugae
Platypus wilsoni
Pseudohylesinus grandis
Scolytus praeceps
S. subscaber
S. ventralis
Semanotus litigiosus
Tetropium abietis
Trypodendron bivittatum
Xylotrechus abietis
X. undulatus

Chamaecyparis lawsoniana. Port Orford Cedar

Atimа cristatus
A. dorsalis
Phloeosinus cupressi
P. sequoiae
Semanotus ligneus var. ampla

Juniperus occidentalis. Western Juniper

Callidium californicum
Chrysobothris nixa
C. viridicyanea
Diaspis carueli
Phloeosinus juniperi
Trachykele juniperi

Larix laricina. Eastern Larch, Tamarack

Anoplodura canadensis
Coleophora laricella
Dendroctonus simplex
Dryocoetes americana
Lygaeonematus erichsonii

Larix occidentalis. Western Larch

Cacoecia fumiferana
Chrysobothris carinipennis
C. caurina
C. dentipes
Melanophila drummondi
Tetropium velutinum

Libocedrus decurrens. Incense Cedar

Argyresthia alternatella
A. libocedrella
Atimia dorsalis
Chrysobothris nixa
Diaspis carueli
Phloeosinus antennatus
P. hoppingi
P. punctatus
P. vandykei
Semanotus amethystinus
S. ligneus var ampla
Trachykele blondeli

Picea canadensis. Eastern or White Spruce

Adelges abietis
A. similis
Anaplodura canadensis
Cacoecia fumiferana
Chrysobothris pusilla
Dendroctonus piceaperda
Ellopia fiscellaria
Monochamus confusor
Orthotomicus caelatus
Peronia variana
Pinipestis zimmermani
Pityokteines sparsus
Polygraphus rufipennis
Trypodendron bivittatum

Picea engelmanni. Engelmann Spruce

Adelges cooleyi
Cacoecia fumiferana
Dendroctonus engelmanni
Dryocoetes affaber
D. confusus
Ips interpunctus
Melanophila acuminata
M. drummondi
Pinipestis zimmermani
Pissodes engelmanni
Semanotus ligneus
Trypodendron bivittatum

Picea sitchensis. Sitka Spruce

Adelges cooleyi
Synanthedon navaroensis
Asemum atrum
Buprestis aurulenta
Dendroctonus obesus
Dryocoetes affaber
Ellopia ferrideria
Gnathotrichus sulcatus
Halisidota argentata
Hylurgops rugipennis
Ips concinnus
I. interruptus
Melanophila drummondi
Peronea variana
Pissodes sitchensis
Xylotrechus undulatus

Pinus contorta including **P. murrayana.** Lodgepole Pine

Argyrotaenia pinitubana
Asemum atrum
Buprestis aurulenta
B. laeviventris
Chrysobothris breviloba
Dendroctonus monticolae
D. murrayanae
D. ponderosae
D. valens
Dicerca tenebrosa
Hylurgops lecontei
H. subcostulatus
Ips emarginatus
I. latidens
I. oregoni
I. radiatae
I. vancouveri
Melanophila consputa
M. gentilis
Monochamus maculosus
Neodiprion burkei
Orthotomicus ornatus
Petrova metallica
Pinipestis zimmermani
Pityophthorus confertus
P. nitidulus
P. tuberculatus
Recurvaria milleri
Vespamima sequoiae

Pinus echinata. Shortleaf Pine

Buprestis apricans
Chalcophora georgiana
C. virginiensis
Dendroctonus frontalis
D. terebrans
Monochamus titillator
Neodiprion abbotti

Pinus lambertiana. Sugar Pine

Buprestis aurulenta
B. laeviventris
Chrysobothris carinipennis
C. contigua
C. dentipes
Chrysophana placida
Conophthorus lambertianae
Dendroctonus monticolae
D. valens
Ips confusus
I. emarginatus
I. latidens
I. oregoni
Melanophila gentilis
Monochamus oregonensis
Neodiprion edwardsii

Pinus monticola. Western White Pine

Asemum atrum
Cacoecia fumiferana
Chrysobothris dentipes
Conophthorus monticolae
Dendroctonus monticolae
D. valens
Dicerca tenebrosa
Gnathotrichus sulcatus
Hylastes nigrinus
Hylurgops rugipennis
H. subcostulatus
Ips emarginatus
I. integer
I. latidens
I. vancouveri
Melanophila consputa
M. gentilis
M. intrusa
Monochamus maculosus
Neophasia menapia
Pineus pinifoliae
Pinipestis zimmermani
Pityogenes fossifrons
Rhyacionia frustrana

Pinus ponderosa and P. Scopulorum. Ponderosa Pine

Aspidiotus pini
Buprestis aurulenta
B. laeviventris
Chalcophora angulicollis
Chionaspis pinifoliae
Chrysobothris carinipennis
C. contigua
C. dentipes
C. ludificata
C. monticola
Chrysophana placida
Coloradia pandora
Conophthorus ponderosae
Dendroctonus approximatus
D. barberi
D. brevicomis
D. convexifrons
D. monticolae
D ponderosae
D. valens
Dicerca tenebrosa
Graphisurus obliquus
G. spectabilis
Hylurgops subcostulatus
Ips confusus
I. emarginatus
I. integer
I. latidens
I. oregoni
I. ponderosae
Magdalis lecontei
Megastigmus albifrons
Melanophila acuminata
M. atropurpurea
M. californica
M. consputa
M. gentilis
Monochamus maculosus
Neodiprion fulviceps
Pinipestis zimmermani

Pissodes yosemite
Pityogenes carinulatus
Pityophthorus confertus
P. nitidulus
Vespamima sequoiae

Pinus palustris. Longleaf Pine

Buprestis apricans
B. decora
B. lineata
Chalcophora georgiana
C. virginiensis
Chrysobothris dentipes
Dendroctonus terebrans
Monochamus titillator

Pinus radiata. Monterey Pine

Chionaspis pinifoliae
Dendroctonus valens
Eriophyes pini
Essigella californica
Halisidota argentata
Ips confusus
I. plastographus
I. radiatae
Itycorsia sp.
Physokermes insignicola
Pissodes radiatae
Pityophthorus carmeli
Rhyacionia pasadenana
Thecodiplosis piniradiatae
Toumeyella pinicola
Vespamima sequoiae

Pinus rigida. Pitch Pine

Buprestis apricans
B. lineata
B. salisburyensis
Chalcophora georgiana
C. virginiensis
Chrysobothris dentipes
Chrysobothris harrisi
Dendroctonus frontalis
D. terebrans
Ips calligraphus
Monochamus titillator
Neodiprion abbotti
Pissodes strobi

Pinus strobus. Eastern White Pine

Asemum moestum
Buprestis lineata
Callidium antennatum
Chalcophora virginiensis
Chionaspis pinifoliae
Chrysobothris dentipes
C. harrisi
C. pusilla
C. scabripennis
Criocephalus agrestis
Hylobius pales
Hylotrupes bajulus
Ips calligraphus
I. pini
Melanophila fulvoguttata
Monochamus confusor
Neodiprion abbotti
N. lecontei
N. pinetum
Pineus pinifoliae
P. strobi
Pinipestis zimmermani
Pissodes strobi
Pogonocherus mixtus
Rhyacionia bouliana

Pinus taeda. Loblolly Pine

Buprestis apricans
B. lineata
Chalcophora georgiana
C. virginiensis
Dendroctonus frontalis
D. terebrans
Ips calligraphus
I. grandicollis
Monochamus titillator

Pseudotsuga taxifolia. Douglas Fir

Adelges cooleyi
Asemum atrum
Buprestis aurulenta
B. fasciata
B. rusticorum
B. subornata
Cacoecia fumiferana
Chionaspis pinifoliae
Chrysobothris sylvania
Chrysophana placida
Dendroctonus pseudotsugae
Dicerca sexualis
Dryocoetes pseudotsugae
Ergates spiculatus
Galenara consimilis
Gnathotrichus retusus
G. sulcatus
Halisidota argentata
Hemerocampa pseudotsugata
Megastigmus spermotrophus
Melanophila drummondi
Monochamus scutellatus
Neophasia menapia
Phymatodes dimidatus
Pinipestis zimmermani
Pissodes fasciatus
Pityophthorus nitidulus
P. pseudotsugae
Pseudohylesinus grandis
P. nebulosus
Scolytus unispinosus
Sirex californicus
Synanthedon novaroensis
Tetropium velutinum
Trypodendron bivittatum
T. cavifrons
Xylotrechus undulatus

Sequoia sempervirens. Redwood

Phloeosinus sequoiae
Phymatodes nitidus
Semanotus (Anacomis) ligneus var *sequoiae*
Vespamima sequoiae

Taxodium distichum. Bald Cypress

Acmeodera pulchella
Platypus compositus
Trachykele lecontei

Thuja occidentalis. Arborvitae

Argyresthia thuiella
Phloeosinus canadensis
Semanotus ligneus
Thyridopteryx ephemeraeformis

Thuja plicata. Western Red Cedar

Atimia dorsalis
Phloeosinus punctatus
P. sequoiae
Semanotus amethystinus
S. ligneus
Trachykele blondeli

Tsuga canadensis. Eastern Hemlock

Buprestis striata
Cacoecia fumiferana
Chrysobothris scabripennis
Dicerca tuberculata
Ellopia athasiaria
E. fervidaria
Melanophila fulvoguttata

Tsuga heterophylla. Western Hemlock

Cacoecia fumiferana
Chilosia alaskensis
Ellopia fervidaria
Gnathotrichus sulcatus
Melanophila drummondi
Nepytia phantasmaria
Peronea variana
Pseudohylesinus tsugae

THE MORE IMPORTANT HARDWOOD TREES OF THE UNITED STATES AND SOME OF THEIR PRINCIPAL INSECT ENEMIES

Acer saccharinum. Soft or Silver Maple

Anisota rubicunda
Chrysomphalus tenebricosus
Hemerocampa leucostigma
Hypermallus villosus
Hyphantria cunea
Lecanium nigrofasciatum
Phyllocoptes quadripedes
Prociphilus tessellatus
Pulvinaria vitis
Synanthedon acerni
Thyridopteryx ephemeraeformis
Xylina antennata

Acer saccharum. Hard or Sugar Maple

Anisota rubicunda
Chrysobothris femorata
Corythylus punctatissimus
Ennomus subsignarius
Glycobius speciosus
Heterocampa guttivitta
Malacosoma disstria
Paraclemensia acerifoliella
Prionoxystus robiniae
Tremex columba

Aesculus glabra. Buckeye

Aspidiotus juglans-regiae
Hemerocampa leucostigma
Lepidosaphes ulmi

Alnus spp. Alder

Agrilus burkei
Halisidota angulifera
Haltica bimarginata
Hemichroa washingtonia
Malacosoma disstria
M. pluvialis
Prociphilus tessellatus

Betula lutea. Yellow Birch

Agromyza pruinosa
Bucculatrix canadensisella
Dicerca divaricata
Dryocoetes betulae

Betula papyrifera. Paper Birch

Agrilus anxius
Bucculatrix canadensisella
Fenusa pumila
Heterocampa guttivitta
Hylecoetus lugubris
Malacosoma disstria
Phyllotoma nemorata

Castanea dentata. Chestnut

Agrilus bilineatus
Balaninus proboscideus
Corthylus columbianus
Goes tessellatus
Hylecoetus lugubris
Melittomma sericeum
Parandra brunnea

Catalpa speciosa. Hardy Catalpa

Ceratomia catalpae
Itonida catalpae

Celtis occidentalis. Hackberry

Aspidiotus ancylus
Lepidosaphes ulmi
Pachypsylla celtidis-mamma
Pulvinaria vitis

Diospyros virginiana. Persimmon

Citheronia regalis
Dicerca obscura
Euzophera semifuneralis
Heterocampa manteo
Lyctus planicollis
Xylobiops basilare

Fagus grandifolia. Beech

Cryptococcus fagi
Dicerca divaricata
Ennomus subsignarius
Goes pulverulenta
Heterocampa guttivitta

Fraxinus americana. White Ash

Alsophila pometaria
Hyphantria cunea
Leperisinus aculeatus
Lepidosaphes ulmi
Lyctus planicollis
Malacosoma disstria
Neoclytus capraea
N. conjunctus
N. erythrocephalus
Platypus compositus
Podosesia fraxini
Prionoxystus robiniae
Tomostethus bardus

Hicoria sps. Hickory

Chion cinctus
Citheronia regalis
Cyllene caryae
Datana integerrima
Dicerca lurida
Ennomus subsignarius
Goes pulcher
Halisidota caryae
Magdalis olyra
Oncideres cingulata
Phylloxera spp.
Saperda discoidea
Scolytus quadrispinosus
Xyleborus celsus
X. xylographus
Xylobiops basilare

Juglans sps.

Datana integerrima
D. ministra
Halisidota caryae
Hylecoetus lugubris

Liquidambar styraciflua. Sweet or Red Gum

Malacosoma disstria
Thyridopteryx ephemeraeformis

Liriodendron tulipifera. Yellow Poplar

Corthylus columbianus
Hylecoetus lugubris
Macrosiphum liriodendri
Toumeyella liriodendri

Nyssa sps. Black Gum, Torpedo Gum

Malacosoma disstria
Oncideres cingulata

Platanus occidentalis. Sycamore

Corythuca ciliata
Dicerca horni
Hemerocampa leucostigma
Thyridopteryx ephemeraeformis

Populus sps. Cottonwood

Aglais antiopa
Agrilus anxius
A. populi
Cacoecia conflictana
Cryptorhynchus lapathi
Dicerca tenebrica
Hemerocampa leucostigma
Hylecoetus lugubris
Lepidosaphes ulmi
Lina scripta
Malacosoma californica
M. disstria
M. pluvialis
Plectrodera scalator
Poecilonota californica
Prionoxystus robiniae
Saperda calcarata
Stilpnotia salicis

Prunus sps. Cherry

Datana ministra
Dicerca pecterosa
Galerucella cavicollis
Hemerocampa leucostigma
Malacosoma americana
M. disstria
Schizura concinna

Quercus spp. Oak, Eastern spp.

Agrilus bilineatus
Alsophila pometaria
Anisota senatoria
Asterolecanium variolosum
Chion cinctus
Chrysomphalus obscurus
Corthylus columbianus
Eupsalis minuta
Goes tessellata
G. tigrina
Hemerocampa leucostigma
H. manteo
Hypermallus villosus
Lyctus planicollis
Malacosoma disstria
Nygmia phaeorrhoea
Paleacrita vernata
Phyllonorycter hamadryadella
Phymatodes variabilis
Prionoxystus robiniae
Prionus spp.
Romaleum rufulum
Smodicum cucujiforme
Zeuzera pyrina

Quercus spp. Oak, Western spp.

Aegeria mellinipennis
Agrilus angelicus
Andricus bicornis
Asterolecanium variolosum
Ellopia somniaria
Hemerocampa vetusta
Malacosoma californica
M. constricta
Neoclytus conjunctus
Phryganidia californica
Plagiotrochus suberi
Prionoxystus robiniae
Prionus californicus
Xylotrechus nauticus

Robinia pseudoacacia. Black Locust

Chalepus dorsalis
Cyllene robiniae
Ecdytolopha insiticiana
Prionoxystus robiniae

Salix sps. Willow

Aglais antiopa
Agrilus politus
Cryptorhynchus lapathi
Hyphantria cunea
Lepidosaphes ulmi
Lina interrupta
L. scripta
Malacosoma disstria
M. pluvialis
Nygmia phaeorrhoea
Porthetria dispar
Prionoxystus robiniae
Stilpnotia salicis

Tilia glabra. Basswood or Linden

Aglais antiopa
Alsophila pometaria
Erannis tiliaria
Hemerocampa leucostigma
Hylecoetus lugubris
Malacosoma disstria
Paleacrita vernata
Prionus laticollis
Saperda vestita

Ulmus spp. Elm

Aglais antiopa
Alsophila pometaria
Chionaspis americana
Datana ministra
Eriosoma spp.
Galerucella xanthomelaena
Gossyparia spuria
Hemerocampa leucostigma
Heterocampa bilineata
Hylurgopinus rufipes
Hyphantria cunea
Kaliofenusa ulmi
Malacosoma disstria
Nygmia phaeorrhoea
Paleacrita vernata
Porthetria dispar
Prionoxystus robiniae
Saperda tridentata
Scolytus multistriatus
Zeuzera pyrina

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